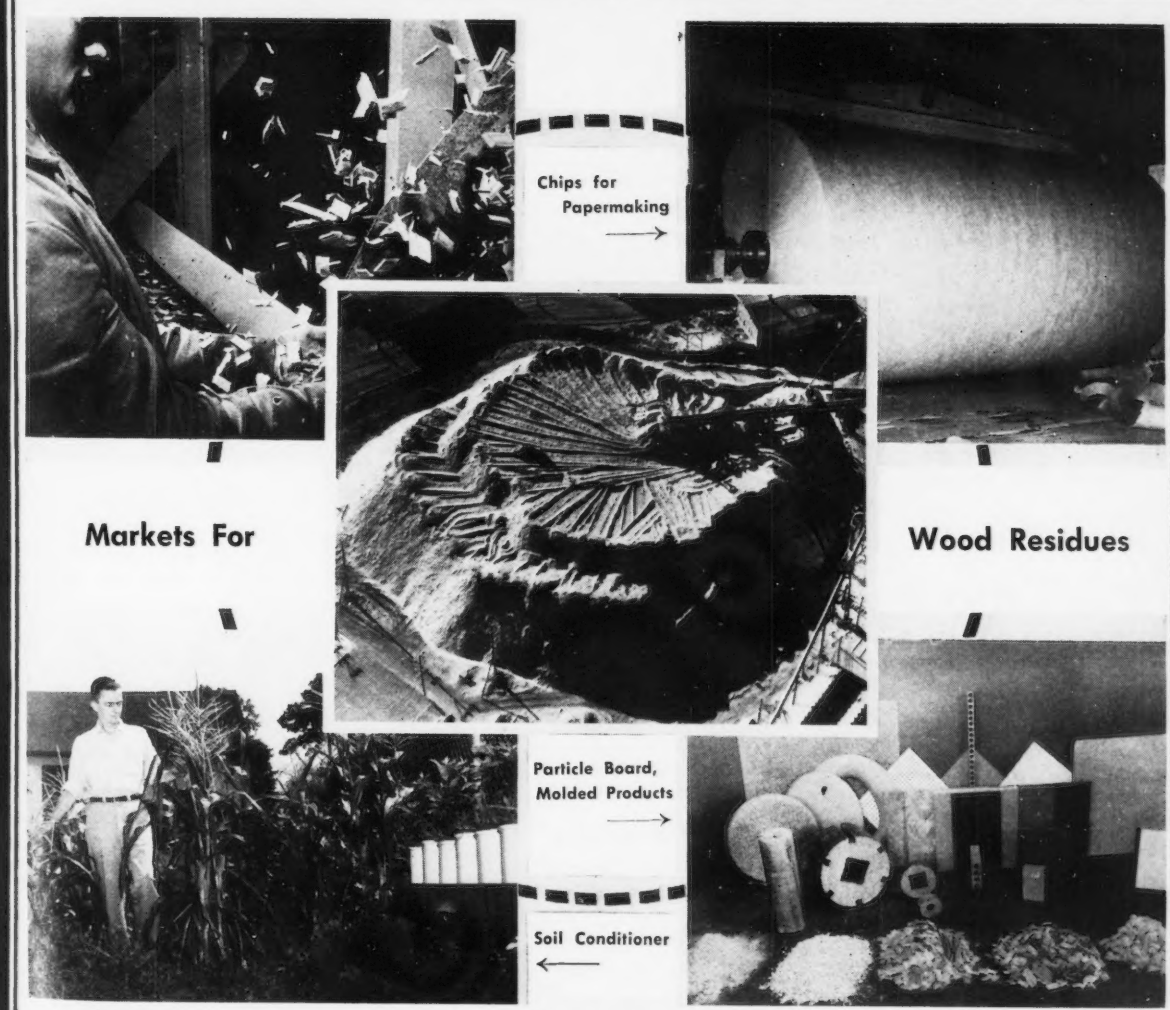
FIVE ARTICLES ON FUTURE WOOD MARKETS

Forest Products Journal

Vol. VI, No. 8 August, 1956



Products from Residues Increase Profits, Open Door to Full Utilization—pp. 279, 281, 17–A

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NO GLUE FAILURE IN THREE YEARS!

URAC® 185 *solves serious gluing problems for White Furniture Company*

White Furniture Company—"The South's Oldest Maker of Fine Furniture"—has *permanently* solved its gluing problems with Cyanamid's URAC 185 Resin Adhesive. Until White started using URAC 185 three years ago, difficulties were encountered in gluing and shaping woods into proper leg and column thicknesses and curved portions. *Since using* URAC *185, there hasn't been one reject or complaint due to glue failure.*

This solid success story is being duplicated throughout the woodworking industry!

Craze-resistant URAC 185 is an excellent gap filler, sets at room temperature with low pressure, and is also highly suitable for hot-press operations. Moisture- and rot-resistant, URAC 185 is incomparable for assembly gluing; bonding decorative laminates, plywood and hardboard; lumber core bonding. The bond is stronger than the wood itself.

If you have a bonding problem, URAC 185 may solve it for you.

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FOREST PRODUCTS JOURNAL

Vol. VI, No. 8 August, 1956

CONTENTS

Page

FPRS News-Digest ---- 9–A, 25–A

WASTE UTILIZATION

Reducing Sawmill Waste 90 Per Cent in Six Years ---- E. P. Ivory 279
Chip Yield and Materials Balance as Related to Log Size in the California Pine and Fir Region ---- N. T. Shelton 281
The Past, Present, and Future of Wood Utilization ---- J. R. Wilner 17–A

RESEARCH

Research Facilities for Small Forest Products Industries ---- P. H. Graham 285
Research and Wood Use ---- R. N. Jorgensen 18–A

CHEMICAL UTILIZATION

Wood—The Future Chemical Raw Material ---- E. G. Locke 289

SAWMILLING

A Look Ahead in Northeastern Sawmilling ---- F. C. Simmons 292
Handbook for Small Sawmill Operators—Glossary and Appendix ---- W. J. O'Neil and J. P. Sims 302

CONSTRUCTION

The Future of Wood in Construction ---- Beryl Price 296
Laminates in Building—1975 ---- R. I. Solow 19–A

FURNITURE MANUFACTURE

Furniture of the Future ---- R. Willard 299

UTILIZATION

Properties, Uses, and Production of Engelmann Spruce ---- I. V. Anderson 307

PAINTS

Swelling of Paint Films in Water: VIII. Swelling of Linseed Oil Paints in Water and Organic Liquids ---- F. L. Browne 312

DEPARTMENTS

FPRS Employment Service ---- 12–A
Around the World in Forest Products Research ---- 21–A
Abstracts from Current World Literature ---- 22–A
Review of FPRS Section Meeting Papers ---- 23–A
Meet FPRS 100 Company Supporting Members ---- 24–A
Index to Advertisers ---- 28–A

IMPORTANT FPRS DATES

Sept. 24–25, 1956: Joint Meeting of Inland Empire and Pacific Northwest Sections, Lewiston, Idaho

Oct. 16, 1956: Upper Mississippi Valley Section Meeting, Wausau, Wisconsin

Fall 1956: Carolinas–Chesapeake Section Annual Meeting, Pinehurst, N. C.

Fall 1956: Mid-South Section Annual Meeting, Laurel, Miss.

Oct. 24–25, 1956: Midwest Section Meeting, Rockford, Ill.

Oct. 25–26, 1956: Northeast Section Meeting, New York City

Dec. 7–8: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

March 1957: Eastern Canadian Section Annual Meeting, Montreal, Quebec

June 24–28, 1957: Eleventh National Meeting, Buffalo, N. Y.

For the newest in coated abrasives . . . watch BEHR-MANNING !

Garnet Finishing Paper is tops for all your hand sanding operations.

Adalox Belts are favorites for cleaning up rough edges and glued areas.

Tufbak Paper is a natural for wet-sanding between coats.

Sanding curves right on the nose !

A BEHR-MANNING Abrasive Belt powered over a stationary nose block by an Upright Spindle Sander does the job quickly and easily on this wood mirror frame. This is a typical example of the successful results obtained when the right BEHR-MANNING coated abrasive is teamed with up-to-date machinery and methods.

Though your operations may be different, a BEHR-MANNING Field Engineer will gladly survey your problem jobs . . . suggest a solution . . . and prove his recommendation right in your plant. Write Behr-Manning, Troy, N. Y., Dept. FP-8

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▲ COATED ABRASIVES
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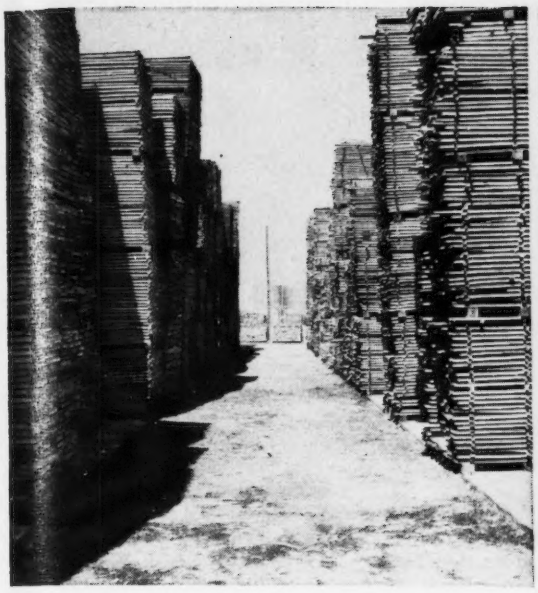
▲ PRESSURE-SENSITIVE TAPES



2 new chemicals

give positive, low-cost grass and weed control

DOW RADAPON*

For grasses, cattails and Phragmites

Here is a new chemical spray which gives positive results on all common grasses. Developed by Dow Chemical Company, RADAPON has proved its effectiveness in exhaustive tests.

Use RADAPON to keep grass out of storage yards, alleys, sidings and ditches. It is effective even on plants in standing water, making chemical control of cattails in ditches practical. RADAPON saves time and money and eliminates use of large crews and heavy equipment to keep ditches clean.

For control of weeds as well as grasses, RADAPON may be mixed with 2-4-D or 2-4-5-T formulations.

DOW BARON*

For both grasses and broad-leaved weeds

Longer-lasting chemical weed control is now possible with new BARON, a non-selective herbicide.

This highly-effective liquid spray is absorbed through both leaves and root system. It remains in the soil for extended periods of time, giving control of germinating seedlings following initial treatment.

BARON controls both broad-leaved weeds and grasses. Use it to eliminate unsightly, unwanted vegetation that creates fire hazards, breeds insects and rodents, and reduces plant efficiency.

**Trade Mark Dow Chemical Company*

Features of Radapon and Baron

Consistent results • Economical
Mix easily with water
Easy to apply • Safe

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Chapman Chemical Company
P. O. Box 138, Memphis 1, Tenn.

Please send complete data on Radapon and Baron for weed and grass control.

Name _____

Address _____

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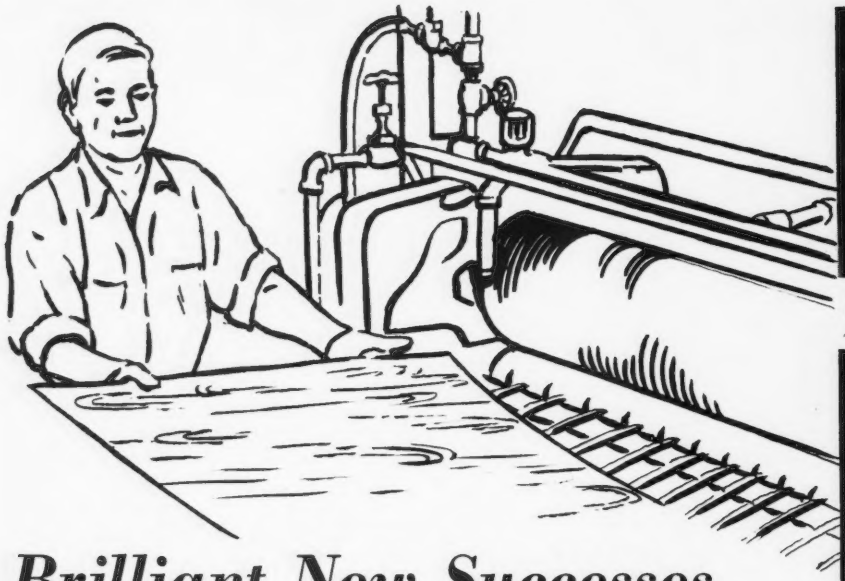
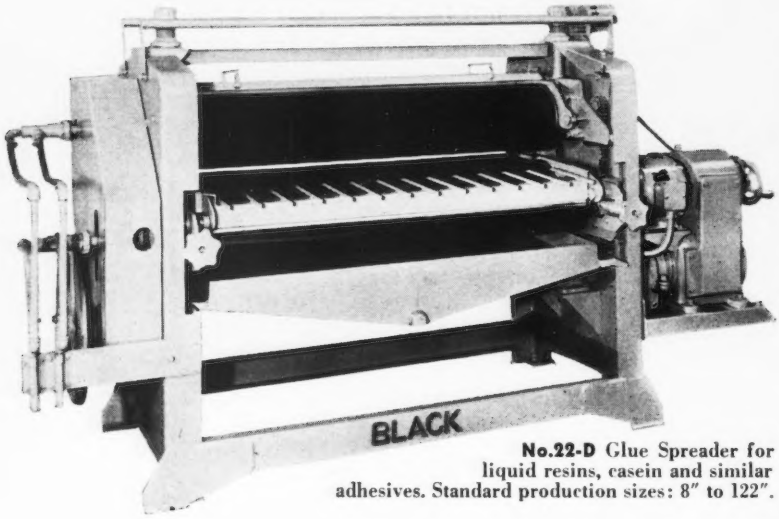
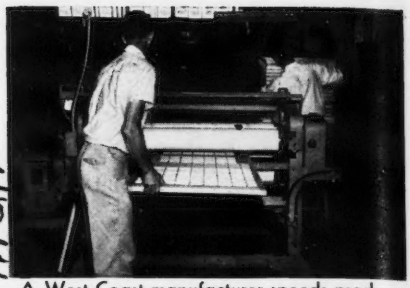


Brilliant New Successes in Gluing and Laminating



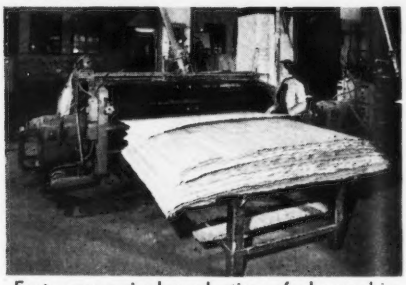
No.22-D Glue Spreader for liquid resins, casein and similar adhesives. Standard production sizes: 8" to 122".



A West Coast manufacturer speeds production of hollow core flush doors with the No. 22-D, 50".

For glue testing and development work, a leading glue manufacturer depends on the No. 22-D Spreader.

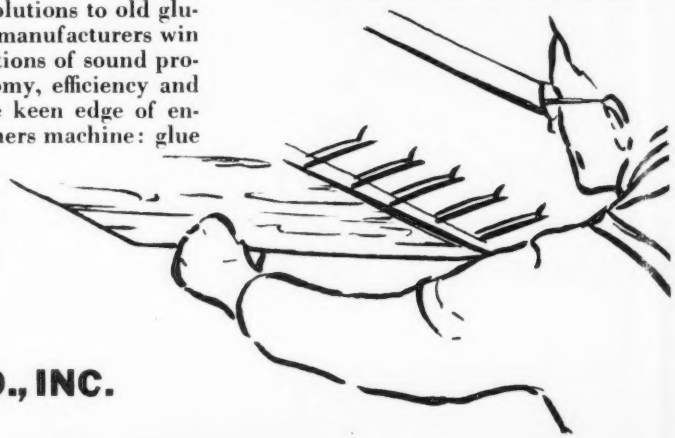
Versatile No. 22-D Spreader helps produce laminated beams and roof trusses at a California mill.



Fast, economical production of plywood in a Finnish plant. The No. 22-D, of course.

On production lines, in glue rooms and laboratories . . . Black Brothers Gluing and Laminating Equipment provides new solutions to old gluing and laminating problems. Helps cost-conscious manufacturers win new competitive markets, too, through new applications of sound production techniques. Preferred for its proven economy, efficiency and speed, the versatile No. 22-D Spreader reflects the keen edge of engineering skill incorporated into every Black Brothers machine: glue spreader, mixer, press or clamp.

Shouldn't you consider a Black Brothers installation? Write for our Supplement to Bulletin No. 11-A which gives construction details and specifications on the No. 22-D Glue Spreader.

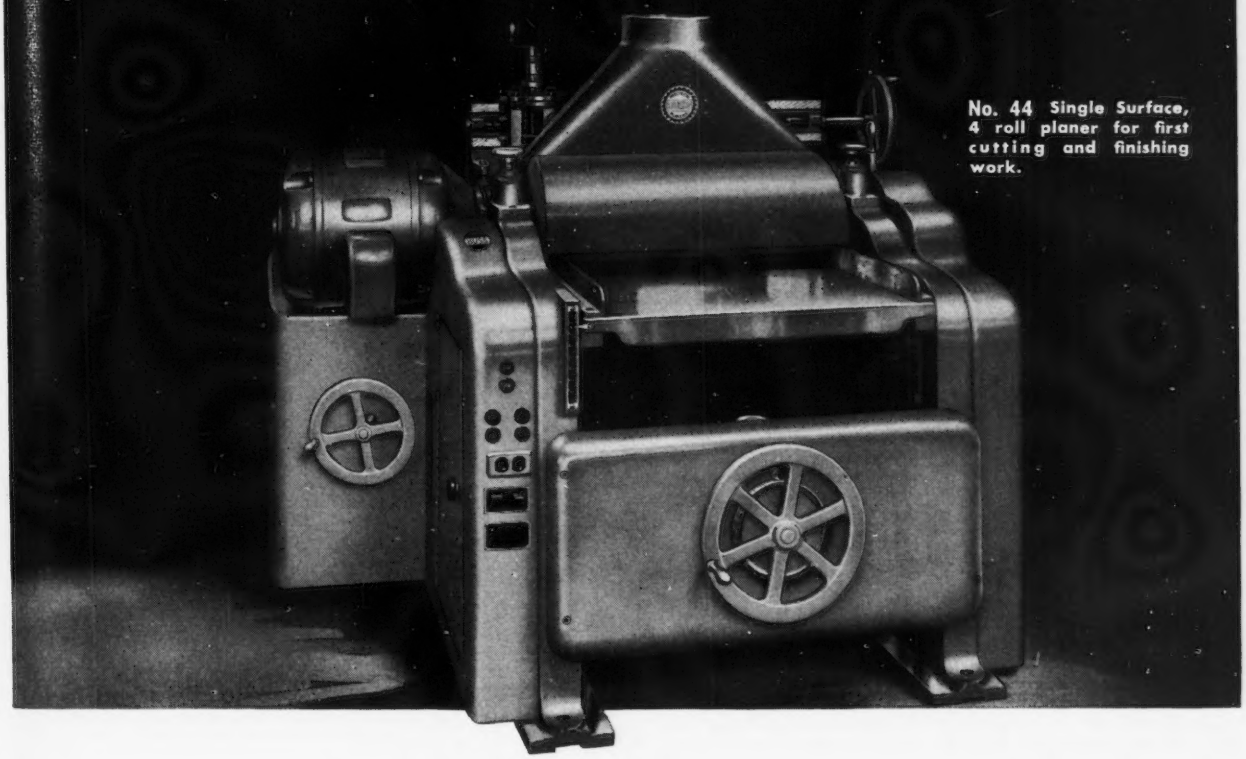


THE BLACK BROTHERS CO., INC.

Here's why

BUSS CABINET SURFACERS

ARE UNMATCHED FOR PRECISION PLANING



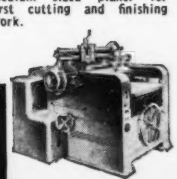
No. 44 Single Surface, 4 roll planer for first cutting and finishing work.

It takes a good mechanic exercising real skill and taking plenty of time for adjustments to produce first class finished planing on the conventional machine. On the other hand, an average operator will ***consistently*** produce ideal finished planing on a modern BUSS CABINET SURFACER and maintain tolerances as close as .002 an inch with only about one-third the non-productive time for set-ups and adjustments required on other planers. This is due to the fact that in addition to being built throughout for precision planing, BUSS CABINET SURFACERS are equippd with semi-automatic controls (not available on other machines) which make it easy for the operator to get perfect and almost instant settings. For the greatest production of the kind of planing that saves time on following operations, investigate BUSS CABINET SURFACERS. Write for bulletins. Consult us on any planing problem.

THERE'S A BUSS PLANER TO EXACTLY SUIT YOUR NEEDS

6 MODELS
29 SIZES

No. 44 Single Surface, medium sized planer for first cutting and finishing work.



No. 66 Single Surface, 6 roll planer for first cutting and finishing work.

No. 88 Double Surface, 8 roll planer for first cutting and finishing work.

No. 55 Heavy Duty Double Surfacer for planing rough lumber.

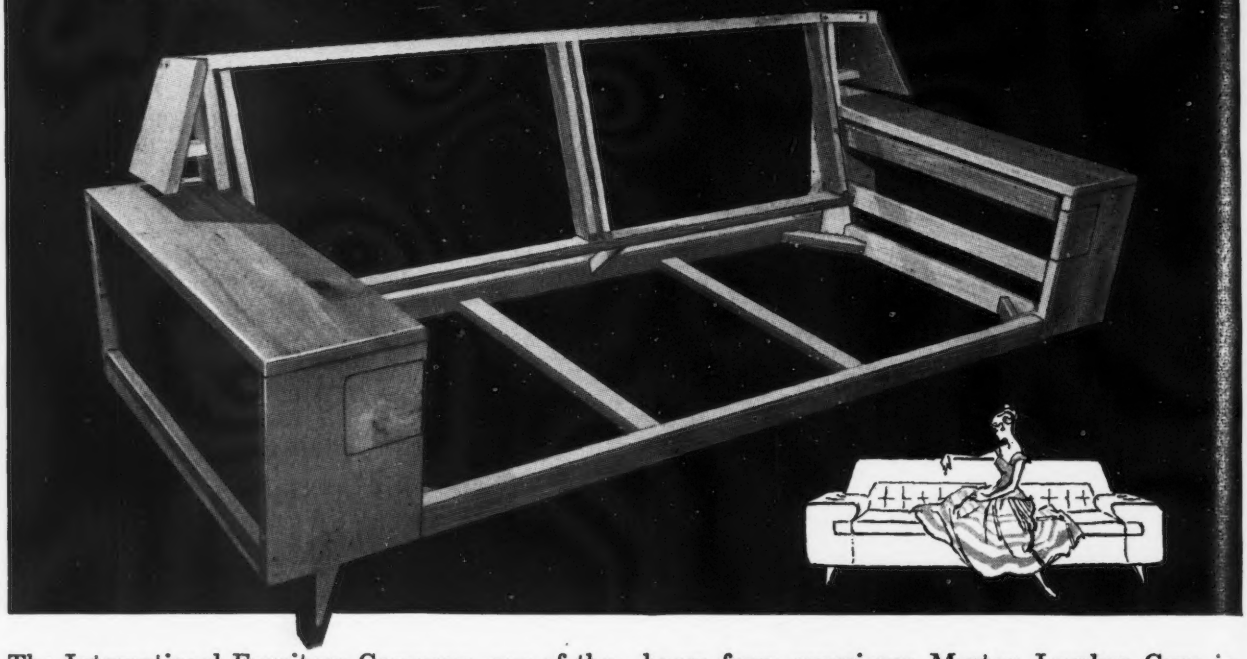
MICRO-SURFACER for planing hardboard and other very thin materials.

BUSS MACHINE WORKS
SINCE 1862

PLANER SPECIALISTS EXCLUSIVELY

792 EIGHTH STREET • HOLLAND, MICHIGAN

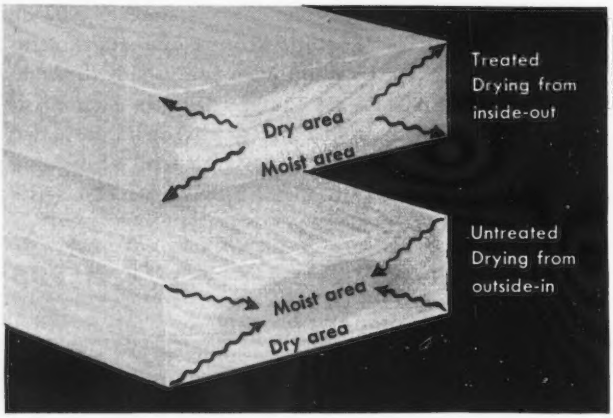
Leading manufacturers insist on Morton Lumber Cure treated lumber



The International Furniture Company, one of the leading furniture manufacturing companies, and makers of the sofa frame shown above, has been using Morton Lumber Cure treated lumber since 1948. International has found Morton Lumber Cure greatly increases yield; reduces end checking, surface checking, and tear-outs.

Hundreds of fabricators now insist on lumber that has been treated with Morton Lumber Cure. They know from experience Morton Lumber Cure increases utilization of rough cut lumber. Lumber also can be dried faster, kiln time and expense are reduced, with a more rapid turnover of inventory and capital.

What's more, Morton Lumber Cure is compatible with stain-preventing agents . . . will not affect gluability . . . machinability . . . color or finish. Morton Lumber Cure is non-toxic and non-corrosive.



How Morton Lumber Cure Works • Morton Lumber Cure reverses the normal drying action. Untreated lumber dries from the outside in. Morton Lumber Cure dries lumber from the *inside out.* This controlled drying greatly reduces checks, honeycomb, warping, and other types of wasteful surface and interior degrade.

SEND FOR MORE INFORMATION TODAY!

Bay Chemical Company
DIVISION
Morton Salt Company

120 So. La Salle Street, Dept. FPJ-8, Chicago 3, Illinois

Please tell me how Morton Lumber Cure can help *me* increase my sales and satisfy customers.

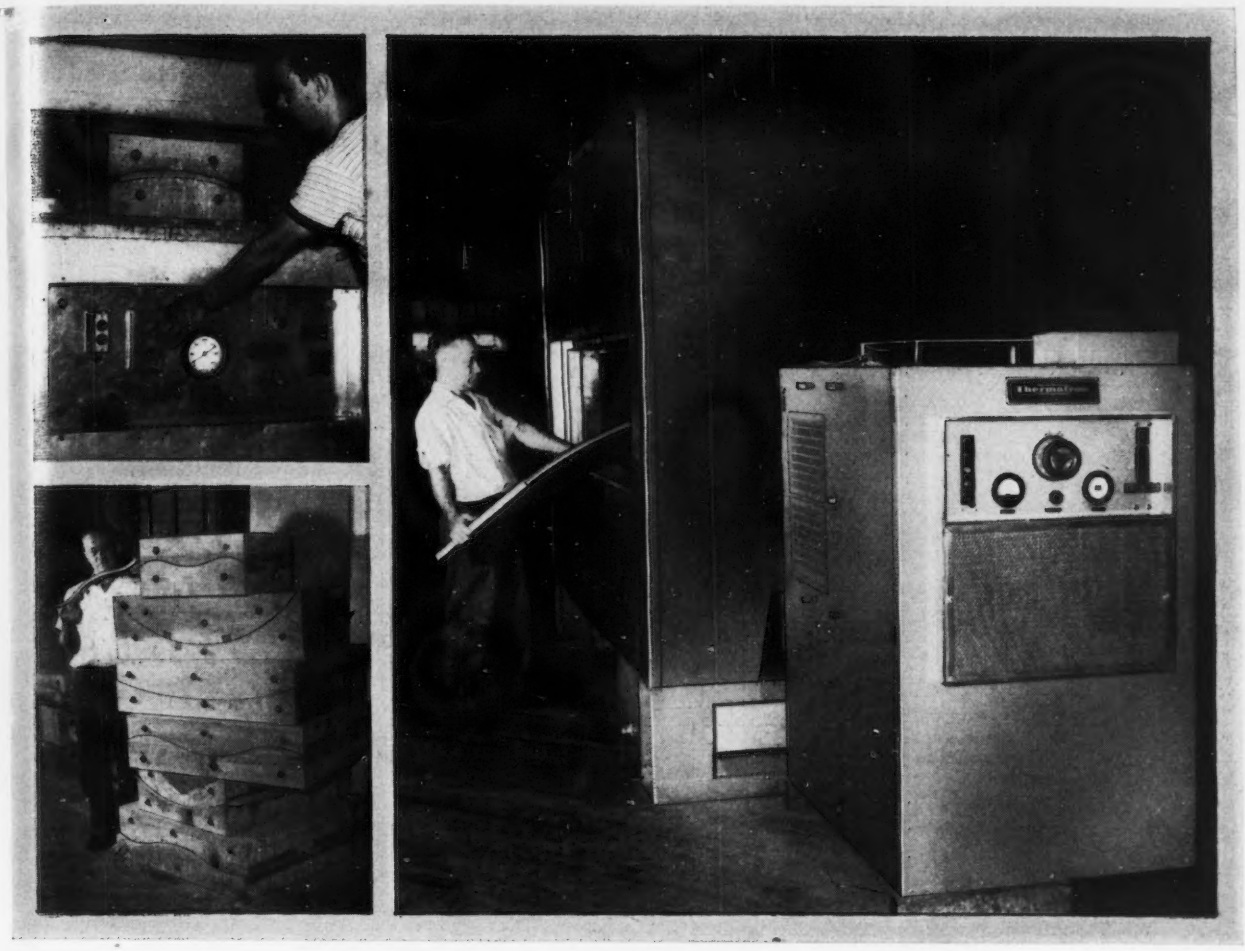
Name_____

Title_____

Company_____

Address_____

City_____ State_____



Now Pennsylvania Furniture Co. bends and laminates fine veneer serpentine fronts in a fraction of the former time with THERMATRON

The old method of gluing in a cold press used to require almost three hours, but the THERMATRON high frequency installation in Pennsylvania Furniture Co.'s York, Pa. plant has created a revolution! Using the 15 KW output THERMATRON generator and 225 ton plywood forming press illustrated, as many as several layups of six to ten pieces of veneer are precision bent and laminated at once over their inexpensive hardwood moulds . . . And the time cycle is no more than 2¾ *minutes*. Other than loading, it's a push-button operation throughout, with no special skills required.

We'd like to survey *your* present operation. We can prove that THERMATRON high frequency equipment will do a superior job while it slashes away at costs. Frees large drying areas for more profitable purposes, too. Write or phone us now without obligation — And ask for our latest bulletin # FP-10.

Thermatron Division

RADIO RECEPTOR COMPANY, INC.

In Radio and Electronics Since 1922

Thermatron®

HIGH FREQUENCY SEALING AND HEATING EQUIPMENT

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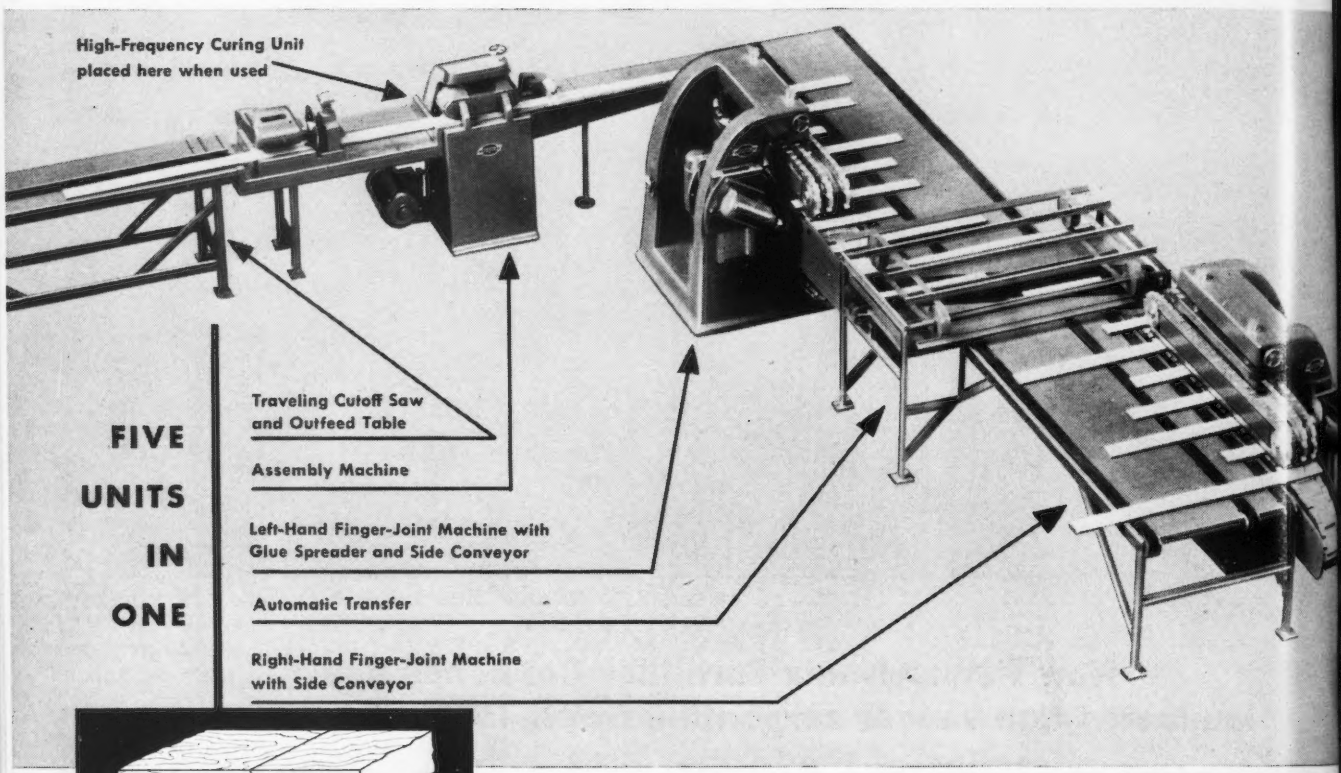
MACHINERY & TOOLS

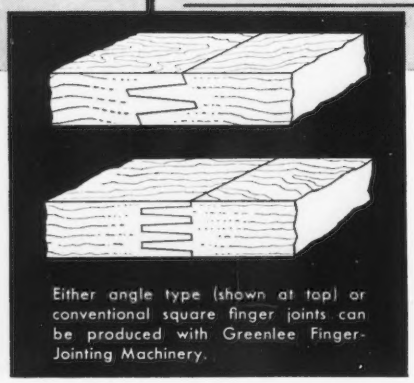
GREENLEE ANNOUNCES

automatic FINGER-JOINTING MACHINERY

an improved method of salvaging and upgrading lumber


High-Frequency Curing Unit placed here when used
FIVE UNITS IN ONE
Traveling Cutoff Saw and Outfeed Table
Assembly Machine
Left-Hand Finger-Joint Machine with Glue Spreader and Side Conveyor
Automatic Transfer
Right-Hand Finger-Joint Machine with Side Conveyor

PHOTOGRAPH OF A MODEL



Either angle type (shown at top) or conventional square finger joints can be produced with Greenlee Finger-Jointing Machinery.

Automatically processes stock up to 2" thick and 6" wide

The wide range of this Greenlee machinery, which handles random stock lengths from a minimum of 6" and in thicknesses up to 2", makes it highly versatile for meeting most lumber upgrading or salvaging requirements. If you are now scrapping stock in these dimensions, you may find this one of the finest production investments you can make. May we make a study with you?

Accurate, high-speed production means extremely low cost per finger joint

Now, the full merit of the finger joint can be efficiently utilized to bring big material savings and new profits to you. With the new Finger-Jointing and Assembly Machine developed by GREENLEE, you can economically upgrade lumber and reclaim thousands of feet of random-length scrap stock per day. A typical mill now being built by GREENLEE can do all this: (1) Cut off stock, score, cut the right-hand finger joint; (2) automatically transfer the stock and feed it into the second machine, which, in turn, cuts the matching left-hand joint; (3) apply glue to the joint; (4) assemble the stock for a tight, smooth fit of the matching joints to make one continuous length of lumber; (5) cut off the assembled stock at a predetermined length and kick it off the outfeed table. Due to the high speed and advanced machining methods of this new GREENLEE equipment, cost is low for each finger joint . . . a fraction of the added value taken on by providing uniform, long lengths of stock! If lumber is a basic raw material for you, it will pay you well to investigate this profit-making new machinery. Write for descriptive folder.

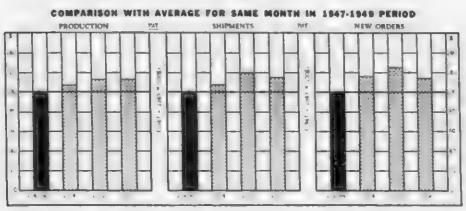
GREENLEE BROS. & CO., 1758 TWENTY-FIRST AVE., ROCKFORD, ILL.

FPRS NEWS-DIGEST

Volume VI AUGUST, 1956 Number 8

GRAPHIC TRENDS

Lumber and Hardwood Flooring Report by NLMA—May 1956



ESTIMATED VALUE OF FOREST PRODUCTS HARVESTED IN MINNESOTA 1955

	PRODUCT	AMOUNT HARVESTED IN MINNESOTA	PULPWOOD SHIPPED OUT OF STATE CORDS	PULPWOOD SHIPPED OUT OF STATE VALUE	PULPWOOD SHIPPED MINN. MILLS CORDS	VALUE OF PRODUCTS PROCESSED OR USED IN STATE CORDS	VALUE OF PRODUCTS PROCESSED OR USED IN STATE UNIT VALUE	VALUE OF PRODUCTS PROCESSED OR USED IN STATE TOTAL VALUE	TOTAL VALUE
1	PULPWOOD	883,111 Cords	275,493	5,785,355	607,618	*829,509	153.12	127,019,645	132,805,000
2	LUMBER	201,000,000 Bd Ft					90.00	18,090,000	18,090,000
3	FUELWOOD	800,000 Cords					15.00	12,000,000	12,000,000
4	CHRISTMAS TREES	5,800,000 Pieces					1.15	6,670,000	6,670,000
5	POSTS	7,300,000 Pieces					.35	2,555,000	2,555,000
6	MATCHWOOD	45,000 Cords					49.90	2,245,500	2,245,500
7	SHAVINGS SAWDUST	620,000 Tons					2.50	1,550,000	1,550,000
8	MINING TIMBER	16,000,000 Bd Ft					60.00	960,000	960,000
9	POLES	150,000 Pieces					4.75	712,500	712,500
10	RAILROAD TIES	360,000 Pieces					2.15	774,000	774,000
11	CHEMICAL	141,606 Tons					5.09	720,000	720,000
12	VENEER WOOD	6,000,000 Bd Ft					90.00	540,000	540,000
13	MILL REFUSE	200,000 Tons					2.50	500,000	500,000
14	PILING	350,000 Lin Ft					.70	210,000	210,000

* Though 829,509 cords were processed in the State in 1955 Minnesota mills pulped 868,967 cords of pulpwood and chemical wood pulp of which 261,354 were imported

TOTAL... $180,332,000

VALUE OF FOREST PRODUCTS harvested in Minnesota has increased from $78 million in '44 to $180 million in '55, as shown by chart above. Forest Industries Information Committee estimates that when 100 persons are added to payroll, 174 jobs are actually created in community.

PRESERVATION USE GAINS—Volume of wood treated with preservatives in '55 increased 3% over previous year, according to summary by U. S. Forest Service, wood preserving plants, and AWPA. Total use (exclusive of dip, spray, and brush treatments, farm and home use) amounted to 25[illegible] million cubic feet, compared to [illegible]50 million in '54. Use of pentachlorophenol inceased 18%, use of creosote declined 3%.

—What's Happening in Forestry

BUSINESS OUTLOOK

TIMBER IS NEW KING in South, according to report issued by Blue Book of Southern Progress. Forest products took cotton's crown by annual output of $4.26 billion in 10 primary southern pine producing states, compared with farm crop output of $4.15 billion. Sawtimber production in South has increased steadily, with '55 output of 8.7 billion board feet, up 9.3% over 54 and 13.9% over '53 production.

—Advertising Age

SUBSTANTIAL INCREASES continued in furniture industry in May, with month's shipments 17% ahead of same month in '55, the industry's best year. Shipments maintained record of 20% ahead of last year for first five months. Orders were 10% above '55, but cancellations continued climb and were 37% greater in first five months compared to same period in '55.

—NAFM

TREND TOWARD LARGER HOMES was noted in survey of FHA-insured houses, with square feet of floor space increasing from 838 in '50 to 1,029 in '55. Typical house last year had 5½ rooms, with three bedrooms. Bigger homes not only use more building supplies, they require more furniture to fill them.

—Housing Trends

SALES UP ONE-THIRD in first quarter of '56 over same period last year are reported by Wood Office Furniture Institute. Business spark has been supplied by intensive efforts of wood office furniture manufacturers to get businessmen to replace obsolete furniture.

—Veneer Newsletter

SOCIETY NEWS

Machinery Demonstrations to Highlight Midwest Meeting

The Midwest Section has set the date for a combined meeting on woodworking machinery and demonstrations of machinery in operation at Rockford and Beloit, Ill. plants. The meeting will be held Oct. 24 and 25 at the Faust Hotel, Rockford.

General chairman of the meeting and machinery demonstration is Walter Hagstrom, Advertising Mgr., Mattison Machine Works. Program chairman is Harvey J. Gill, Jr., Carr, Adams & Collier, Dubuque, Iowa. Other members of the arrangements committee include Section Chairman L. J. Fitzpatrick, J. J. Fitzpatrick Lumber Co., Madison, Wis.; Wm. A. Kluender, Chicago & Northwestern Railway System, Chicago, Ill.; J. F. Koellisch, Wood & Wood Products Magazine, Chicago; J. J. Allegretti, Masonite Corp., Chicago; and Dwight Bensend, Iowa State College, Ames.

The theme of the meeting devoted principally to woodworking machinery will be "How to get the most out of new and existing machinery." Registration will start the evening of October 23 and technical sessions will be held on the mornings of October 24 and 25.

Machinery demonstrations will be held both afternoons at the Ekstrom Carlson, Greenlee Tool, Mattison Machine Works and Yates–American plants. Others may be added. These manufacturers will have the latest machinery on display, in some cases complete lines. Much of the machinery will be in actual operation with raw materials being processed. In addition, the committee has left Friday, October 26, open for the convenience of persons desiring to visit further with machinery manufacturers on that date, through personal arrangement.

Other persons who attended the initial steering committee meeting include Alan Mattison, Pres., Mattison Machine Works; J. A. Lengquist, Sales Manager, Greenlee Tool Co.; Harold Nelson, Pres., Ekstrom Carlson Co.; and R. L. Hiller, FPRS North–Central Regional Board Member and technical representative, American Cyanamid Co. Lawrence Bramble, Sales Mgr., Yates–American; P. L. Mattison, Vice-Pres., Mattison Machine Works; and John E. Hyler, John E. Hyler & Assoc., Peoria, Ill., were invited but unable to be present at this meeting.

The Midwest Section last held a similar program and machinery demonstration in Rockford in November 1950. General chairman at that time was Harold Nelson of Ekstrom Carlson Co. The meeting, one of the largest ever held by an FPRS Section, attracted 356 registrants. It is believed that the meeting this year will attract a similar number of interested woodworking people.

Two Sections Planning Regional Meeting in Idaho

Arrangements are being completed for a two-day joint meeting of the FPRS Inland Empire and Pacific Northwest Sections Sept. 24 and 25 in Lewiston, Idaho. With the Inland Empire Section as host, the meeting will afford Pacific Northwest members an opportunity to visit an outstanding inland lumber and paper industry, differing in many respects from the fir and associated industries of the northwest.

The program committee has attracted at least two speakers of national standing for the meeting. In addition, FPRS President Ralph H. Bescher is making a trip west to attend and W. Jeter Eason, newly installed Vice-President, has indicated a desire to be on hand for the sessions.

Technical programs are scheduled for mornings of both days, with both afternoons free for plant tours. Each Section will prepare and conduct a technical session, with details to be announced in the near future.

Potlatch Forests, Inc., at Lewiston, operates one of the largest pine mills in the industry, sawing virtually all the inland species. An outstanding research staff and laboratory are maintained. The operation is completely integrated, with veneer plant and plywood factory, hydraulic barking and chipping, and a 600-ton pulp and paper mill utilizing sawmill waste from all Potlatch mills and others.

Waste Utilization Theme Of Pacific Southwest Meeting

Uses for wood waste were discussed by three speakers at a dinner meeting of the Pacific Southwest Section June 20 at Swallys Key Club, Los Angeles. George Miller of Miller Bros. Co. spoke on utilization of fine grind granulated wood, covering species, moisture content range, various pressing and molding processes, and related factors.

Use of coarse grind and larger particle wood waste was the topic of Bill Ripley of Molded Products Division, Stauffer Chemical Co. He reported on processing, moisture content, equipment, and temperatures. John M. Crafton of Chipcraft Co., discussed the extrusion process of making particle board, including preparation of the wood, species, and the various stages of manufacture.

See page 25-A for New Product News

Ten Firms Aid Section Student Scholarship Awards

Contributions of $50 each have been received from ten firms to assist in the annual student scholarship program of the Eastern Canadian Section. Participating in the program are Northern Wood Preservers Ltd., Reichhold Chemicals (Canada) Ltd., Moore Dry Kiln Co. Ltd., Canada Creosoting Co. Ltd., Abitibi Power & Paper Co. Ltd., Monsanto (Canada) Ltd., Forano Ltd., Dominion Electrohome Ltd., General Woods & Veneers Ltd., and International Panel Boards Ltd.

Membership in the Eastern Canadian Section has increased to 237 and the Section won first prize at the National Meeting in Asheville for greatest percentage membership gain. A three-fold policy has been established by the Section officers: to promote greater Canadian membership in FPRS, to hold one worthwhile annual Section meeting, and to encourage interest in wood utilization among Canadian undergraduates by annual scholarship prizes.

Veneer and Plywood Theme For Upper Mississippi Meeting

The Upper Mississippi Valley Section plans an afternoon and evening meeting on Oct. 16 in Wausau, Wis., with veneer and plywood as the principal discussion topic. A technical paper and plant tour are tentatively scheduled for the afternoon, followed by a dinner and keynote speaker from the industry.

Mid-South Section Schedules Meeting in Laurel, Miss.

The Mid-South Section will hold its Annual Meeting Oct. 29 and 30 at Laurel, Miss. A tour of the Masonite Corp. plant is planned. Principal sessions will be held in Hotel Pinehurst, and social events will be at the new Laurel Country Club. Additional accommodations may be obtained at the El Patio Motel. The meeting is under the direction of John Wells, Section Chairman, and J. J. Cope, Section Secretary.

Cash for Back Journal Copies

The Executive Office needs copies of the following back issues of the Journal: Vol. II, Nos. 1 and 2 (April and June 1952). $2.00 each will be paid for copies in good condition. Send to: Forest Products Research Society, Box 2010, University Station, Madison 5, Wis.

INDUSTRY NEWS

N rth Carolina Firm Plans P ticle Board Operation

ormation of American Parboard C p. to manufacture particle board h been announced by officials of M rgan Manufacturing Co., Black M ntain, N. C. Installation of ma- cl ery will be completed this fall and c mercial production is expected to st early in 1957.

resident of the new firm is Harold R. Tipton, formerly head of several lu ber and furniture plants in the So h and East. David B. Morgan, Jr. is xecutive Vice-President and Arthur H Haigh is Technical Director.

he company will produce particle bo d from selected Appalachian hard- w ds in thicknesses from 3/8 to 1¼ in es. Made in 5 by 8-foot sheets or ut to size as required, the board wil be marketed under the name "Parboard".

NAFM Features Woodworking Technology and Market Trends

Better understanding of newest advances in woodworking technology and the sweeping changes taking place in today's furniture market are expected to result from the National Association of Furniture Manufacturers' 1956 Supply, Equipment & Fabric Fair and 28th Annual Convention. The Fair and Convention will be held August 26–30 at the Conrad Hilton Hotel, Chicago.

More than 2,500 furniture and woodworking executives and representatives of allied industries are expected to attend the meetings and study more than 125 exhibits prepared to give them up-to-date technical advice and information on the newest production aids.

The meeting theme will be "Changing with the Times", with interpretations of the latest facts and figures on general business and industry trends. A session on finishes, sponsored by the National Paint, Varnish, & Lacquer Assn., will be moderated by J. A. Hager, Grand Rapids Varnish Co., with panelists G. A. Lenseus, Southern Varnish Corp.; W. D. Lawson DuPont Finishes Division; R. I. Quigley, Lilly Co.; and F. H. Thomas, Sherwin–Williams.

An industrial relations session will feature panel discussions on training and supervising personnel. A. L. Fader will speak on "What Modern Machinery Means to Costs and Sales" at a luncheon meeting on August 29.

FPRS will have an educational display designed to stimulate wider interest in furniture industry research and development. Examples of latest furniture technology will be demonstrated, including a wide selection of particle boards and low-grade woods that are adaptable for use in furniture.

PROPER LUMBER STACKING METHODS were explained to U. of Michigan wood technology students by E. F. Rasmussen (center) during recent visit to U. S. Forest Products Laboratory. At right center is Prof. N. C. Franz, who accompanied student group.

Several FPRS individual and company members will take part as exhibitors at the Fair. Firms represented will include: Adamson United Co., Armstrong Machine Works, Dean Co., Decar Plastic Corp., Deluxe Saw and Tool Co., Farley and Loetscher Mfg. Co., Fiberesin Plastics Co., Gamble Bros. Inc., Curt G. Joa, Inc., Masonite Corp., Morgan Mfg. Co., National Adhesives, Nelsonite Chemical Products, Inc., North American Products Corp., Perkins Glue Co., Serge A. Birn Co., Seng Co., Spotnails, Inc., Timber Engineering Co., U. S. Plywood Corp., and Wood Conversion Co.

Firm Broadens Science Scholarship Program

Continuation on a broader basis of his firm's scholarship program in chemistry and chemical engineering has been announced by Frank Greenwall, President of National Starch Products, Inc. Participating schools are N. C. State College, State U. of New York College of Forestry, Columbia University, Case Institute of Technology, Rutgers University, and University of Nebraska.

The program was initiated to help alleviate the serious shortage of technical graduates. Applicants in the two general fields must be of outstanding scholastic ability, high character, and need financial assistance. Scholarship recipients are under no obligation as to future employment with the sponsoring firm.

NLMA Directors Vote Expansion of Research

An expansion of research activities was authorized by directors of the National Lumber Manufacturers Association at their spring meeting May 28–30 in Seattle, Wash. Other resolutions congratulated the U. S. Chamber of Commerce for its work in modernizing building codes and cited the National Paint, Varnish and Lacquer Association for cooperating with NLMA in a program to improve paint performance on wood.

The directors approved a one-year study of "condensation problems resulting from air conditioning of homes" and a two-year project aimed at development of "improved practices for unit packaging, shipping, handling and storage of lumber and lumber products." Both projects will be undertaken at the laboratory of Timber Engineering Co.

Forest Products Lab Employs Student Aides

Twelve U. of Wisconsin students are working at the U. S. Forest Products Laboratory this summer as participants in a new program aimed at training them in the skills and techniques of scientific research. The students, all of whom have completed one or two years in chemistry or engineering, are serving as technicians and laboratory aides.

The trainee program was begun to "encourage college students to think seriously about scientific research and its opportunities," according to Dr. J. A. Hall, Director. He expressed "strong hopes that some of these young men will decide to make research their lifelong career." Dr. Hall pointed out that the program will be broadened in future years to obtain trainees from other parts of the country and that physicists, biologists, technologists, foresters, and possibly others may be hired.

New Fiberboard Plant Planned in Michigan

Plans have been announced for a $6 million fiberboard plant at L'Anse, Mich., to be built by Celotex Corp. as part of its $22 million expansion program. Celotex has a purchase agreement with Ford Motor Co. and Ford Motor Co. Fund for acquisition of 242,000 acres of timberland and an existing plant site in the L'Anse area.

SHORT COURSES

Penn State Schedules Sawmill Training Course

A small sawmill training course will be held August 29–31 at Pennsylvania State U., University Park, Pa. The course will cover determination of profitable logs, choice of products, relation of stumpage values to log size and grade, grading and scaling, small mill equipment, economical use of men and machines, preventive maintenance, selection and care of saws, waste reduction, power needs, lumber handling, seasoning problems, marketing, and related items. Demonstrations will be given at a local mill.

Fee for the course is $15 for Pennsylvania residents, $20 for non-residents. Application blanks and further information may be obtained from the Short Course Office, Dairy Bldg., Penn. State U., University Park Pa.

Finishing and Quality Control Courses Planned

North Carolina State College has scheduled a short course in furniture finishing August 27–31 and a course in statistical quality control for the pulp and paper industries Sept. 10–14.

The finishing course, to be held at the Lilly Co. plant in High Point, N. C., will cover airless spraying, multi-colored coatings, and color-masking toners. Other special features will include reduction of overspray, hot-lacquer coatings, finish repair of touch-up, and reduction of defects.

The quality control course will be held at Cataloochee Ranch, 40 miles west of Asheville, N. C. Discussion topics will include quality control charts and quality control in continuous operations, batch processes, and purchased materials. Other topics will be inspection techniques and equipment, advanced techniques, organization of a quality control program, and operations analyses.

Six-Day Kiln Drying Clinic in Massachusetts

The New England Kiln Drying Association's annual six-day kiln drying clinic is scheduled Sept. 10–15 at U. of Massachusetts, Amherst. Instruction will be by personnel from the U. S. Forest Products Lab., Northeastern Forest Experiment Station, and the University.

Registration fee for the course is $50, with enrollment limited to 25 persons. Full details are available from Prof. Harry Rich, Conservation Bldg., U. of Massachusetts, Amherst.

NAMES IN THE NEWS

Robert C. Rhodes has been appointed to a sales and management capacity with Chapman Chemical Co., to serve in western Washington, western British Columbia and Alaska. He formerly operated Rhodes Chemical Co., Gate, Wash., recently purchased by the Chapman firm.

Appointed Product Development Engineer at the Seattle plant of U. S. Plywood Corp. was **A. H. Rauch,** formerly in charge of wood technology at the Plywood Research Foundation, Tacoma, Wash.

Dr. Frank H. Kaufert, FPRS Vice-President, left the United States August 9 on a two-month special mission to Korea. He is taking part in a program of re-establishing forestry teaching and forest products research at the National University of Seoul.

K. G. Chesley, Director of the Crossett Co. Research Division and past president of FPRS, has been appointed to the Arkansas Committee on Nuclear Energy by Governor Orval Faubus. The 11-man group will explore potential uses of nuclear energy for the state.

W. R. Ganser, Jr. has joined the staff of the American Institute of Timber Construction as structural engineering assistant, according to **Frank J. Hanrahan,** executive vice-president.

EMPLOYMENT SERVICE

Positions Offered

No. E 232—Forest products research organization desires new or recently graduated forest products or wood technology major, preferably with basic chemistry, advanced degree and/or experience in forest products. Possibility of work in several fields. (Sept.)

No. E 233—Large Midwest institutional furniture company seeks wood technologist and wood finishing laboratory technician. Prefer B.S. degree. Approximate salary range $500. Starting date, September. (Aug.)

No. E 234—Sales manager wanted to handle sales of modern automatic sawmill machinery through dealers and directly. Mechanical engineering or forest products degree preferable but not essential. (Aug.)

No. E–235—Several openings available on staff of an expanding industrial research and development laboratory, located in East. Consideration will be given recent wood technology or utilization graduates, as well as those having 5 to 10 years' experience in forest products fields. Heavy mathematics, engineering, or chemical background preferred.

No. E 240—Several openings available in hardboard and chipcore plants in various sections of the U. S. Seek men with experience in these fields who are capable of managing production. Technical men also needed.

No. E. 242—West Coast wood research laboratory has opening for recent graduate in chemical engineering. Work will involve pilot plant operation in connection with wood extractives, solvent and vapor seasoning, and associated projects. (Sept.)

No. E 243—Wood preserving plant in South seeks man with forestry background for sales position. Principal duties would be securing timber cutting rights. (Sept.)

Employment Wanted

No. 245—B.S. Wood Technology, U. of Minn., age 29, married. Four years' experience with U.S. Navy Bureau of Ships and timber laminating industry. Specializing in quality control. Desires quality control or working out procedure of glues and gluing for plant guidance. (Aug.)

No. 358—Executive with extensive managerial experience in design, construction, installation, and operation of chipcore plants. (Aug.)

No. 359—Purchasing agent or sales engineer, nine years' experience. Presently with large chemical company serving New England state; previous experience in pulp and paper, creosote and lumber industries. Five years as forester and procurement agent. M.S., Yale Forestry School. Age 29. (Aug.)

No. 360—Wood waste utilization. B.S. Chem. Engr., M.S. Chemistry. Age 26, married. 15 yrs. experience rubber, hardboard, wood waste, chemical utilization, dissolving pulp, and wood particle board. Presently Asst. Plant Mgr. of wood particle board mill; full knowledge of wood fluing; familiar with all phases of wood particle board industry. Desires supervisory position in research, development, technical service, or production. (Aug.)

No. 361—B.S., botany major, age 33, presently primer shop engineer; five years' experience, design of new equipment, experimental work, quality control. One year as chemical control worker in explosives. Northeast. (Aug.)

No. 362—Supervisor, hardboard plant; B.S. forestry for wood production (honor graduate). Age 28, single. Presently located West Coast; assisted in pilot plant development of hardboard process for one-half year. Assisted in start-up of 150-ton hardboard production plant, one year. Two years production supervision. Has also had teaching and professional laboratory experience. (Aug.)

No. 363—B.S. Forest Mgt., N.C. State, 1950. 5-1/2 years experience in timber marking, field examination, some surveying, logging operations: desire location within 200 mile radius of central N.C. Will consider any opportunity related to forestry, utilization, sales, etc. (Aug.)

No. 364—Will graduate September, Wood Tech., N.C. State College. Prefer New England. Interested in particle board; thesis work concerned with "springback" in flat press boards. Desires research or management opportunity. Married. (Aug.)

No. 365—Wood Technology graduate B.S., U. of Minn., June '54. Age 23, single, excellent scholastic and employment record, veteran as of Sept. '56. Seeks research or production position. (August)

No. 366—University of Michigan Wood technology graduate, holds degree of Forester–Engineer from Germany, seeks production or managerial position in the wood industry. Master of five languages, would like position with opportunity for advancement. Age 29, married.

No. 367—Civil engineer, cabinet maker, 25 years' experience in sawmilling, plywood, housing, and furniture, desires position as industrial engineer or administrator in U.S. or Canada. Broad experience in Europe, Canadian citizen, age 42.

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FPRS Forest Products Journal

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Reducing Sawmill Waste 90 Per Cent in Six Years[1]

E. P. IVORY

President, Ivory Pine Company of California, Dinuba, Calif.

Various merchantable products made from formerly wasted materials have helped reduce one firm's sawmill residues from nearly 300 to about 30 tons per day. Full utilization within the next five years is expected. The influences on by-product outlets of species sawn, methods of manufacture, and geographical location are pointed out.

SAWMILL WASTE can be reduced, and in some cases eliminated, by either a large or small sawmill. However, the methods employed vary greatly with such factors as species sawn, methods of manufacture, and geographical location. Each set of factors will bring about different forms of waste utilization and each such use will be the result of long study on management's part to fit into the markets that are available.

Having stated the proposition and named factors, this paper will show their application at the Ivory Pine Company at Dinuba, California. This mill saws each year about 25 million feet of timber, consisting of 70 per cent true fir species—*concolor* and *magnifica,* and 30 per cent of pine—ponderosa, jeffrey, and sugar. Both types are fitted for many of the usual waste uses, such as car strips, pulp chips, or baled shavings. White fir, being relatively free from resin and odor when dry, also has special qualities fitting it for such uses as a plastic base and grape packaging.

The mill uses purchased electric power, applied largely through the medium of hydraulic fluid. It has no steam plant, even for the kilns. Logs are debarked with a rossing type of machine that turns the log fairly smooth and gives off many tons of bark and splinters of wood from the knots. Lumber is produced in typical yard sizes. It is seasoned both in the air and in kilns, and planed before shipment.

The mill site at Dinuba is in the heart of the San Joaquin Valley at an elevation of 350 feet. Timber grows at 6,000 to 8,000 feet 35 miles as the bird flies and 50 miles by road from the mill. It is surrounded by vineyards, orchards, melons, and cotton, and there are large oilfields within 50 miles. Rainfall averages about 9 inches per year but the runoff from the mountains fills several large streams and puts much water into the subsoil.

On The Cover

Mountains of wood waste are being utilized in variety of products. Chips are used in making paper and board products, molded products and soil conditioner are among uses for smaller particles. Top left photo courtesy Wood and Wood Products magazine; center and lower left photos, Timber Engineering Co.; photos at right, Oregon Forest Products Laboratory.

The San Joaquin Valley is 248 miles long and averages 50 miles wide. It contains 7,736,000 acres of land that is very productive when irrigated. Its agricultural production is valued at $1.097 billion per year. The principal crops in order of value are cotton, dairy products, and grapes or their derivatives, raisins and wine.

Fresno County, from which logs are obtained, is reputed to be the largest agricultural producer among all counties in the United States. Tulare County, where the sawmill is located, and adjoining Kern County are among the top ten counties, as are two other counties nearby. The San Joaquin Valley has a population of 1,020,600 with three cities in the 100,000 class. The Los Angeles-Southern California market with 6 million people is 250 miles south of Dinuba and 215 miles north is the San Francisco Bay area with 2½ million people. All are connected by good highways, as well as railroads.

This will give some idea of the geographical features and of the local market. It is a fertile field in which to look for by-product outlets.

With no boilers to consume waste, there was going into the burner each day before the salvage program was started four years ago approximately 292 tons of waste made up of: 62 tons of bark dust, 67 tons of green sawdust, 98 tons of slabs and edgings, 33 tons of shavings and dry dust, and 32 tons of other waste, such as rot, chunks, and debris.

The first attack was on slabs and

—Photo courtesy Oregon Forest Products Laboratory

Fig. 1.—Chipped material is shipped 175 miles to paper mill in open-top box cars.

[1] Presented at Session X, Logging and Milling, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: E. P. Ivory received B.S. degree from N. Y. State College of Forestry, Syracuse, was formerly associated with U. S. Forest Products Laboratory, Western Pine Assoc., and Weyerhaeuser Sales Co. He is past Chairman of the FPRS Northern California Section.

edgings for the production of car strips. These are similar to lath and are used as a form of dunnage in loading cars of fruit. There are produced and shipped each year slightly over 3 million car strips within a radius of 50 miles of the mill, with 80 per cent delivered within 15 miles. These strips are made from fairly clear slabs and edgings. Production is around 14,000 pieces per day, which puts 8 tons of waste to use.

The mill is 175 miles from a large paper plant to which it ships approximately 45 tons per day of chipped material. Slabs and edgings not suitable for car strips, which are free from bark and of sound fiber, are reduced to chips and blown some 900 feet in an underground conduit to the railroad track where they are loaded into an open-top box car. Planer trims and broken boards are also chipped. As the debarker does not remove all the bark and there is often rot, chunks, and large pieces of bark from the pond, there is still considerable chunk material going into the burner from this part of the operation.

There has also been a great deal of green sawdust going into the burner from the sawmill. It runs from 40 to 80 tons per day, depending on the size and kind of logs being sawn, and averages 67 tons. This has been a difficult item to dispose of but, for about a year now, large amounts of it have been sold to poultry producers and dairymen within 100 miles of the sawmill. It goes out in truck and trailer lots of 22 tons. For weeks at a time this use takes all of it but there are times when two or three days will pass without orders. If this sawdust were dry, there would be a market for all of the white fir dust in the packaging of grapes for export shipment and for grinding into wood flour. A program for drying is in the planning stage and it is believed that another four months will see all white fir dust put to use. When it is, we are confident that all the pine sawdust will go into the lower grade use of chicken litter. Thus, there will be eliminated continuously an average of 67 tons per day of material that would have to be burned.

That brings us to planing mill waste utilization, chiefly use of shavings and sawdust. In point of time, this was one of the early installations at the plant. A separator was put into a large cyclone so that the coarse shavings could be separated from the sawdust and fine particles. The dust and fine particles were graded into three different sizes, which find a market within 100 miles of the plant for such uses as butcher floor covering, sweeping compound, fiber for prepared roofing and wall board, bean cleaning, fur cleaning, and grape packaging. Oil companies use vast quantities in their drilling operations. Most of them keep 10 to 15 tons on hand, but it is not unusual to get a call in the middle of the afternoon advising that their drilling bits struck a void and they need 10 tons by 8 o'clock the next morning. That is not difficult where there is only 60 or 100 miles to haul.

Fig. 2.—One man operates sacking department for Forest Humus and Orchid Bark. Complete sceening, grinding, and sorting equipment is in rear.

For some uses, species must be segregated. The bean cleaner wants nothing but pine—the pitchier the better. Export grape packers want dry white fir that is completely free from resin and odor. This market is capable of absorbing 3,000 tons per year at $35 per ton.

Approximately 30 tons per week of wood flour is ground from the residue of white fir sawdust. This has to pass through a minimum screen of 70 mesh and the bulk of it, 70 per cent or more, must pass through a 100-mesh screen. Our customers mix approximately 10 per cent by weight of resin with this wood flour and form it under pressure and heat into such commodities as toilet seats, lazy susans, and electrical components. They want flour that is free from resin and dried to less than 8 per cent moisture content. Both pine and fir can be ground, but the pine grinds slowly and only the white fir is sufficiently free from resin so that molders can duplicate their formulas time after time.

Shavings are put into bales containing 5 cubic feet and weighing approximately 70 pounds. They have to be compressed, tied in between wood lath with baling wire, and covered with paper. They are used by chicken growers, nurserymen, dairymen, and many small users, such as on athletic fields in spring time. There is produced between 85,000 and 100,000 bales per year, or 3500 tons, that bring approximately $15.50 per ton at the plant and cost about $9.50 per ton to put up. Of course, shavings must be dry. Generally, species does not matter. Minor species such as incense cedar, when run through the plant occasionally, furnish a special lot of bales that are prized for chicken nests, dog litter, and similar uses.

That leaves the big fraction of granulated bark dust—an average of over 60 tons per day. There are two broad outlets for this—the first in the form of composted material for farm, home, and nursery use, as suggested by the agricultural nature of the Valley. This fraction has nitrogen added to it in the form of aqueous ammonia or ammonium sulphate solution as it is tossed off the log. It is then placed in long windrows 20 feet wide, 5 feet high, and 500 feet in length. Originally, bacteria was added to start the decomposition rapidly, but it has been found that there are so many bacteria on the logs and so much soil picked up as they are dragged in the woods that the addition of starting bacteria is unnecessary. Three to five days after the material is put out, bacterial action develops temperatures within the mass between 130 and 140 degrees. This continues upwards of three months, when the bacteria die down, the pile cools off, and various molds take over.

Nitrogen producing material is then added and turned into the heap. In the past, there were used tons of cull tomatoes, plums, or peaches from the many packing plants in the vicinity, or dump truck loads of chicken viscera from the poultry processing plants. This takes considerable effort and leaves residues of pits that are objectionable. Now there is being worked into the piles at this time some form of ammonium salts in solution. It is injected 9 to 12 inches below the surface by applicators as are used in the fields. The bacteria promptly develop again and temperatures soar to 140 degrees. The process of composting goes forward rapidly. Bark seems to break down much more rapidly than the woody content and white fir again does the best job. The composting process takes about six months. It could be speeded up if more labor were used in turning, watering, and other stages of processing.

When composting is completed, the material is sold in bulk in loads of 10 or 20 tons at approximately $8 per ton, F.O.B. the plant. Lately sacking equipment has been added and it is sold through nurseries, seed stores, and other outlets under the name of Forest Humus. This brings a higher return but costs much more. The sacks alone, which must be polyethylene lined, cost 25¢ each. The sacks proclaim that the material "Brings the Bounty of the Forest into Your Garden". Both nurserymen and home owners find it a

valuable soil amendment. Its pH is on the acid side and in a region where the soil is alkaline and even the irrigation water registers a pH of 8.2, that is important.

While working on this composted bark program, it was found that some customers preferred the raw white fir bark and thereby hangs a tale that is a real romance of business. One was a soil specialist who had a number of commercial orchid growers among his clientele. He recommended its use to one of his largest customers, who has a quarter million pots of mature orchid plants on hand at all times. He reasoned that bark was the native element in which orchids grow and the results obtained more than justified his deduction. Plants sent their roots rapidly through the granulated bark, bloomed earlier than usual, could be separated much sooner than customary, and, in many cases, orchid plants that had never done well brightened up at once when placed in the bark and became prolific producers. It developed that white fir bark was important to success and that the rotary method of removing it, possibly because it took some wood, particularly the cambium layer, contributed to successful use. There has been speculation that white fir, since it has a uric acid odor, may contain quantities of urea but in a form that eludes detection under ordinary laboratory methods.

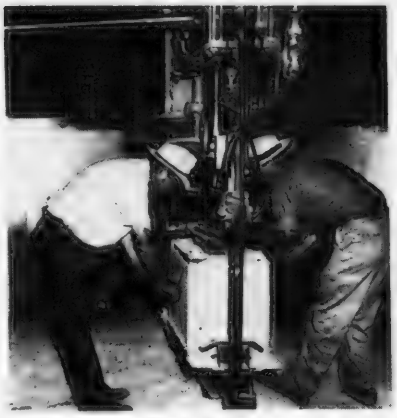

Fig. 3.—Compressed shavings are tied in bales 16 x 30 x 19 inches, containing 5 cubic feet and weighing about 70 lbs.

Reports of this successful use spread by word of mouth and soon orchid growers throughout California were taking over 1,000 tons per year of bark. Not only did they like the results but the cost of the bark was a minor fraction, a 20th or 30th, of what their previous materials had cost. It had required an expert at $3 to $4 per hour to use the previous material and it took 20 minutes to pot a plant. With the true fir bark, any laborer could pot a plant in 7 to 8 minutes. When it came to watering, the fern roots had required careful hand application, but with bark the plants could be completely drenched and the residue ran on through instead of swelling and compressing the roots.

Articles began to appear in the orchid magazines and soon there were requests for samples and shipments from throughout the United States and even Mexico. All reports have been favorable with scarcely a question because their authors were highly successful commercial growers and recognized experts. Many carloads have been shipped into the eastern area and it is believed that the market is just beginning to be tapped. This material is now being put into sacks and within a year should be available to most orchid supply houses throughout the United States.

This completes the roster of waste utilization to date. The input of approximately 292 tons of waste formerly going into the burner in a 24-hour period is now down to 30 to 35 tons. Of course, the moisture removed from the lumber in seasoning has not found a use, neither has the squeal of the pig in the packing house. But one who knows the dryness of the San Joaquin Valley might speculate that even the moisture may yet find its place in the commercial picture.

As for what is going into the burner now, the management believes that it may have it completely black within two years, but that is still to be demonstrated. However, a 90 per cent reduction in sawmill waste in six years is a record of which it is very proud, even though it doesn't cut out the fire altogether.

Chip Yield and Materials Balance as Related to Log Size in the California Pine and Fir Region[1]

N. T. SHELTON

Division Engineer, Diamond Match Co., Chico, Calif.

Planning an integrated forest products industry which completely utilizes timber and wood residue resources requires a means of predetermining the volume in lumber, bark, sawdust, chippable wood, and shavings. The type and design of lumber manufacturing and by-product operations are dependent on a reasonable estimate of quantities to be produced. Case history is given to show procedure used to determine chip yield and materials balance.

PLANS HAVE BEEN MADE by the Diamond Match Company to erect an integrated forest products plant in California. The plant will include a sawmill having an annual capacity of 85 million board feet, together with complete lumber manufacturing facilities, and a molded pulp plant to produce the firm's line of molded egg cartons, foodtainer trays, and duplex plates. The lumber and molded pulp divisions are integrated in the sense that the wood residuals developed by the sawmill in the form of wood chips become the raw material for the pulp mill.

During the early planning stage of the project, it was necessary to obtain reliable data on the quantity of wood chips that would be available. The size and capacity of the sawmill was fixed by the sustained yield of the company's timberlands but the economic size and capacity of the molded pulp operations were determined by the quantity of bark-free chips that would be produced by the lumber manufacturing end.

From various sources, the average yield in units per M net log scale was obtained but these averages varied

[1] Presented at Session X, Logging and Milling, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: N. T. Shelton holds M.E. degree from Cornell U. and is licensed professional engineer. He has been with Diamond Match Co. since 1936, is now responsible for industrial and plant engineering. Vice-Chairman of the FPRS Northern California Section, he is a member of the Milling Division.

widely, ranging from 0.2 to 0.9 units per M. It was apparent that the chip yield record of others could not be safely applied unless more detailed information was available on the log sawing method, the type of equipment used, the quality of chip produced and, most important of all, the size of log sawn. The ratio of chippable material in a small log is greater than that obtained from a large log and it was recognized that log size had a great deal of influence on the chip yield of other sawmill operations.

The problem was complicated further by the plan to obtain greater utilization of timber resources and to bring in all merchantable trees down to a 6-inch top. The annual cut of 85 million feet, therefore, will consist of logs ranging in size from 6 to over 60 inches in diameter.

It was not possible to compute the yield of green chippable material from any of the firm's past sawmill records. These records gave the log scale and green chain lumber tally per day or shift but this information was not related to log size. However, one source of valuable information, prepared by the company's forestry department, gave the average number of logs of each diameter that would be delivered to the mill annually. If the average green chippable yield per log for a log of given diameter and length could be determined, it would be possible to obtain a reasonable estimate of the wood chip output. With this idea in mind, a sawmill study was undertaken for the dual purpose of obtaining grade recovery and chip yield information.

Table 2.—METHOD OF DETERMINING CUBIC FEET OF GREEN LUMBER PER MBF CHAIN TALLY

Nominal Thickness	Actual Thickness	Actual Width	Actual Length	BF Tally	Cubic Feet	Cubic Feet Per Bd. Ft.
4/4	1 1/32"	4"	16' 3"	5.333	.466	.087
		6¼"		8.000	.727	.091
		8½"		10.667	.989	.093
		12½"		16.000	1.455	.091
6/4	1 13/16"	4"	16' 3"	8.000	.762	.095
		6¼"		12.000	1.190	.099
		8½"		16.000	1.619	.101
		12½"		24.000	2.380	.099
		16"		32.000	3.047	.095
		18"		36.000	3.428	.095
8/4	2 1/4"	4"	16' 3"	10.667	.959	.090
		6¼"		16.000	1.499	.094
		8½"		21.333	2.038	.096
		12½"		32.000	2.997	.094
Average value based on proportion of each thickness and width produced						.093

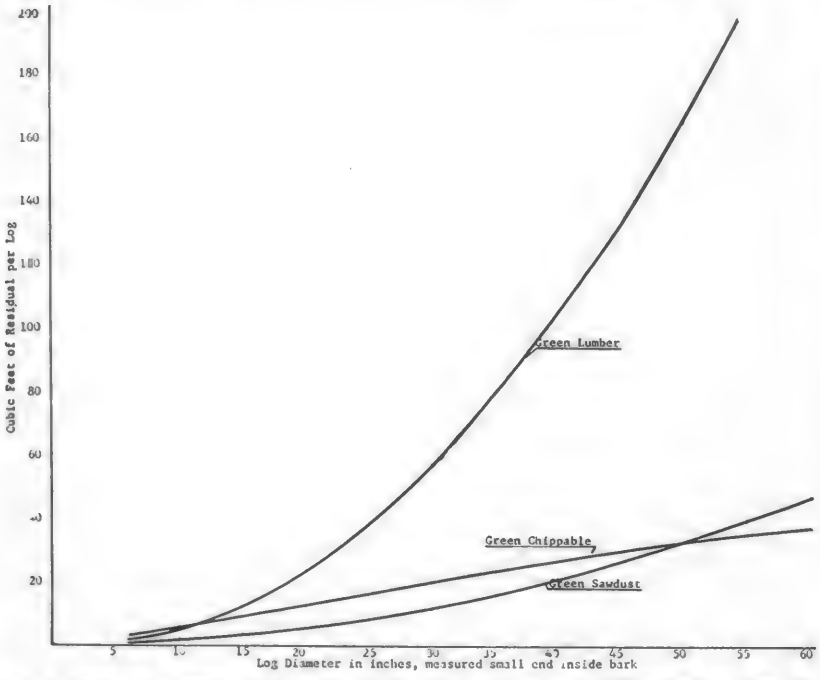

Fig. 1.—Sawmill Materials Balance—cubic feet of residual per 16-foot log for logs of various diameters, measured inside bark at small end.

Sawmill Study Method

A group of employees from the forestry and industrial engineering departments was organized to carry out a sawmill study. This group supplemented the regular sawmill crew and recorded data on each log entering the mill by specie, log grade, type of growth, the Scribner Decimal C log scale, the net log scale, the diameter inside the bark at both ends of the log, actual length of the log, and both the piece tally and grade of the lumber produced by each log.

On completion of the sawmill study, all data were grouped by logs having the same small end diameter. A preliminary inspection showed no significant difference in lumber yield by specie and the proportion of log grades in the sampling was representative of the log grades normally delivered to the mill. Over 3000 logs were classi-

Table 1.—SAWMILL SAW KERF THICKNESSES

Machine	Rig #1	Rig #2	Rig #3
Log deck saw	7/16"	7/16"	7/16"
Band Mill	¼"	5/16"	3/16"
Edger	3/16"	¼"	¼"
Resaw	3/16"	5/16"	3/16"
Trimmer	¼"	¼"	¼"
Slasher	3/16"	3/16"	¼"

Table 3.—SAWMILL MATERIALS BALANCE
Cubic Feet of Material per 16 ft. Log for Logs of Various Diameters
(Data plotted on Fig. 1)

Log diameter measured inside bark, small end	6"		10"		20"		30"		40"		50"		60"	
Cu. ft. material per log for log len. of 16 feet	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	
Green Lumber	1.8	36.0	5.0	43.5	23.0	54.8	58.0	65.8	105.0	68.9	167.0	71.1	246.0	75.0
Green Chippable	2.6	52.0	4.8	41.7	13.3	31.6	17.9	20.4	25.9	17.0	35.0	14.9	35.2	10.7
Green Sawdust	0.6	12.0	1.7	14.8	5.7	13.6	12.2	13.8	21.4	14.1	33.0	14.0	46.8	14.3
Total Log Volume	5.0	100.0	11.5	100.0	42.0	100.0	88.1	100.0	152.3	100.0	235.0	100.0	328.0	100.0
Scribner Decimal C Log Scale	20.0		60.0		280.0		660.0		1200.0		1870.0		2700.0	
BF Lumber Tally	19.4		53.8		247.3		623.7		1129.0		1795.6		2645.1	

fied and recorded in this manner. With this information, it was the objective to find the total volume of the log and deduct the green lumber and green sawdust volume to determine the green chippable volume for each log of a given diameter.

Total Log Volume: The total cubic feet of material in each log was computed from the diameter at each end and the actual log length. Although logs are brought into the mill in 33-foot lengths and cross cut into 16½-foot lengths at the deck saw, an occasional shorter or longer length is brought in from the woods. In order that the calculations would be consistent for a nominal length of 16 feet, the volume of these logs and the quantity of lumber produced from them, were converted to the equivalent of a 16-foot nominal log length.

Green Lumber Volume per Log: The sawmill study recorded the quantity of lumber produced from each log in terms of board feet, and with a knowledge of the actual green thickness, width, and length into which the lumber was sawn, a conversion multiplier was determined. Although the volume in cubic feet per board foot varies slightly with the thickness and width of lumber sawn, an average multiplier was found by the proportion of lumber developed in each thickness and width to establish a value of 93 cubic feet per MBF.

Green Sawdust Volume per Log: Finally, it was necessary to determine what volume of sawdust would be developed by the log deck saw, bandmills, edgers, trimmers, resaw, and slasher in terms of cubic feet per log of a given diameter and length. To do so, a typical sawing pattern was constructed for several log sizes in the range from 6 to 60 inches in diameter. Since the thickness of the saw kerf removed by each machine is known, the volume of material removed by sawing was computed by the tedious process of measuring the thickness, width, and length of each saw cut as indicated by the log sawing pattern. By plotting this information, a curve was drawn so that the cubic feet of sawdust developed by 16-foot logs of any diameter can be found.

Green Chippable Volume per Log: After finding the volume of green lumber and sawdust removed from the log, the balance represents the green chippable consisting of slabs, edgings, trims, and material transferred to the slasher due to incipient rot, shake, and other log defects. This was found by deducting the volume of green lumber and sawdust from the total log volume for each group of logs having the same small end diameter.

The data obtained by this method was tabulated for each group of logs having the same small end diameter. This data, when plotted on a curve sheet, gave the cubic feet of green lumber, sawdust, and chippable material obtained from 16-foot logs of any diameter. If the average number of 16-foot logs of each diameter that will be sawn in the mill is known, it is possible to determine the cubic feet of each class of material that will be produced. Table 3 shows the tabulation of the data for a few of the intermediate size logs and Fig. 1 is the result of plotting this data.

The yield in chips is more commonly expressed in terms of cubic feet or units per MBF. Since the BF tally and the material balance in cubic feet for each log size was known, the yield per MBF was plotted as shown by Fig. 2. This same information is shown for a few of the intermediate log sizes in Table 4.

The yield per MBF here refers to the quantity of green lumber produced rather than net log scale. It was felt that net log scale is an arbitrary value, based on the scale formula used, the judgment and skill of the scaler, and how much he is influenced by the desire of the mill manager to record a satisfactory overrun.

Prior to making the sawmill study, a careful analysis was made of the kiln drying and planing mill losses and since these losses are not affected by the original log size, it was possible to prepare an overall plant material balance which shows the final landing place of all the wood in the log.

It would be dangerous to assume that the results of this study are directly applicable to others unless the conditions are the same in all respects. It is hoped that the study will be useful to others primarily as a suggested method of approach toward solving an awkward problem. In this study, the

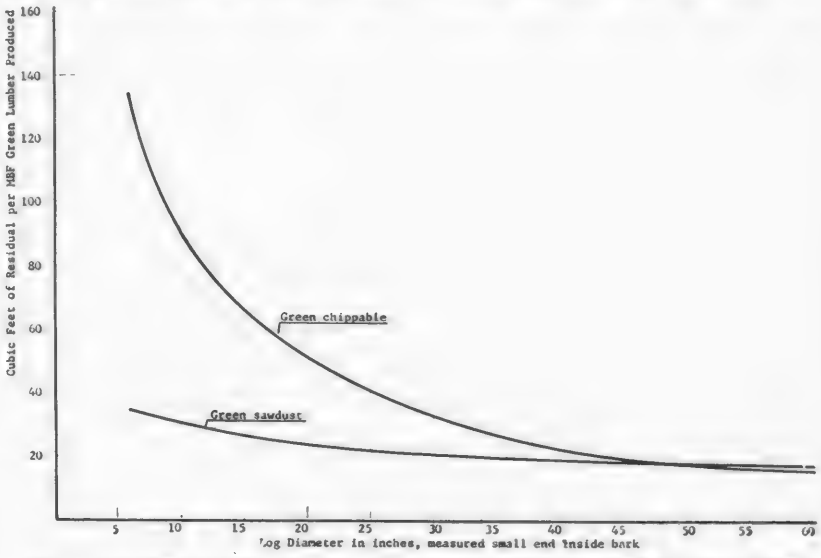

Fig. 2.—Sawmill Materials Balance—cubic feet of residual per MBF of green lumber produced from logs of various diameters.

Table 4.—SAWMILL MATERIALS BALANCE
Cubic Feet of Materials per MBF of Lumber Produced for Logs of Various Diameters
(Data taken from Fig. 2)

Log diameter measured inside bark, small end	6"		10"		20"		30"		40"		50"		60"	
Cubic feet of material per MBF lumber	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%
Green Lumber	93.0	35.7	93.0	43.8	93.0	55.9	93.0	63.7	93.0	68.8	93.0	72.0	93.0	73.8
Green Chippable	134.0	51.4	89.2	42.0	50.0	30.0	32.3	22.2	22.9	17.0	17.8	13.8	15.4	12.2
Green Sawdust	33.5	12.9	30.0	14.2	23.5	14.1	20.5	14.1	19.2	14.2	18.4	14.2	17.7	14.0
Total	260.5	100.0	212.2	100.0	166.5	100.0	145.8	100.0	135.1	100.0	129.2	100.0	126.1	100.0
Units of Chips per MBF based on 85 cu. ft. solid wood per 200 cu. ft. unit	1.58		1.05		.59		.38		.27		.21		.18	

—Photo courtesy Oregon Forest Products Laboratory

Fig. 3.—Pulp chips from sawmill residues are one of keys to complete utilization.

following conditions are assumed, all of which have some effect on the chip yield per log or per MBF:

1. The logs are similar to the pine and mixed conifer timber types located in the Sierra Nevada mountains of northern California. In this study, the predominant species were ponderosa and sugar pine.

2. The average log grade and percentage of log defect have an important effect on the volume of green chippable obtained and the sampling should represent the average log grade of the timberlands.

3. All the logs entering the mill are whole log barked to obtain clean chips.

4. Logs of 10-inch diameter and smaller are slabbed on two sides and "sawn alive" either at the bandmill or the resaw. All logs larger than 10 inches in diameter are sawn to obtain maximum grade recovery.

5. The logs are sawn on bandmills and double thicknesses are resawn after edging and trimming.

6. The end product consists primarily of 4/4 selects & commons, 6/4 shop, box and moulding, and 8/4 common and dimension. No timbers are produced.

7. None of the green chippable material is hogged for fuel or salvaged for lath, stickers, mouldings, or squares.

8. In the chipping plant, the chips are screened and the oversize rechipped.

9. It is assumed that 100 per cent of the green chippable residual can be converted into chips of satisfactory quality.

Discussion

Charles M. Kreider (Brooks-Scanlon, Inc.): Were these logs barked and by what means?

Mr. Shelton: These logs were not barked. It was assumed that the logs were bark-free and all measurements were made inside the bark.

Clark C. Heritage (Consultant): I want to compliment Tom Shelton on his interest and perseverance in carrying through a detailed study of the sawmill, the kilns, and the planing mill to arrive at a precise materials balance for the entire operation. The factual determination of what happens to each cubic foot of wood furnished to the head rig is no small undertaking and the Society, I am sure, is very appreciative of Tom's willingness to make his results available to others.

Each mill initiating a study of integrated utilization of residuals at once encounters the need for knowledge of the yields of the various kinds of products produced by the sawmill and planing mill, from lumber to sawdust and sander flour. The engineering approach to dealing with this matter as a volumetric materials balance with total volume of solid wood in the various products in cubic feet equalling the incoming log volume in cubic feet provides a way to be certain the results are trustworthy and nothing has been overlooked. It is to be hoped that others will follow Tom's example, do similar jobs for other regions, species and log sizes, so that many case studies will be available for reference with results expressed in easily understandable universal units of measurement.

W. W. King (Tennessee Valley Authority): I think it would only be right if I passed on this information for the benefit of those people in the South and elsewhere who do not deal with logs up to 60 inches in diameter. The Texas Forest Service completed a study of this nature several years ago for pine, oak and gum logs ranging in size from 7 to 20 inches inside bark, small end. The study was conducted on a weight basis. All logs were weighed and all components recorded by weight. Results show the chippable, bark, and dust components on both a green and oven dry weight basis for both Doyle and International ¼ inch Log Rules, and also on a green and oven-dry pound tally basis per 1,000 ft. with errors of estimate. If you are interested in this study, write to the Director, Texas Forest Service, College Station, Texas, and ask for Bulletins 3 and 3A.

Anon.: I assume in your study you figured your chip recovery at 100%. In actual practice, what per cent do you think you would get back?

Mr. Shelton: I think there would be quite a wide difference from one operation to another. Much depends upon the operator and the quality of chips he can use. I am not an authority on this subject but think perhaps 95% can be converted into usable chips for most purposes.

Table 5.—PLANT MATERIALS BALANCE

Cubic Feet of Materials per MBF of Lumber Produced for Logs of Various Diameters

Log diameter measured inside bark, small end	6"		10"		20"		30"		40"		50"		60"	
Cubic feet of material per MBF lumber	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	
Green Chippable	134.0	51.4	89.2	42.0	50.0	30.0	32.3	22.1	22.9	17.0	17.8	13.8	15.4	12.2
Green Sawdust	33.5	12.9	30.0	14.2	23.5	14.1	20.5	14.1	19.2	14.2	18.4	14.2	17.7	14.0
Shrinkage in Drying	4.6	1.8	4.6	2.2	4.6	2.8	4.6	3.2	4.6	3.4	4.6	3.6	4.6	3.7
Dry Shavings and Sawdust	15.5	5.9	15.5	7.3	15.5	9.3	15.5	10.5	15.5	11.5	15.5	12.0	15.5	12.3
Dry Trims	2.3	0.9	2.3	1.1	2.3	1.4	2.3	1.6	2.3	1.7	2.3	1.8	2.3	1.8
Dry Lumber	70.6	27.1	70.6	33.2	70.6	42.4	70.6	48.5	70.6	52.2	70.6	54.6	70.6	56.0
Total	260.5	100.0	212.2	100.0	166.5	100.0	145.8	100.0	135.1	100.0	129.2	100.0	126.1	100.0

Research Facilities for Small Forest Products Industries[1]

PAUL H. GRAHAM

Clinic of Wood, Newfane, Vermont

Versatile, diversified, and economical research facilities available to small forest products industries are discussed. Reference sources are given for proper selection and use of these facilities. The knowledge and proper application of research can assist small industries in solving production problems.

RESEARCH IS NO LONGER the exclusive field of the scientist but rather has become an important branch of any business. This is especially true of forest products industries which must now prepare to meet competition of products made from other materials produced by other industries using new techniques in new and progressive designs. These products currently are being offered to forest products markets at greatly reduced prices.

Recognizing a vital need for research and technical development, larger forest products industries have established research departments and have also contracted projects out to service organizations equipped to provide expert advice in various fields of specialization. Management of these successful concerns is said to spend only about 5% of its time dealing with current problems and 95% providing for the future of the business.

Advantages of Research

This management realizes that research properly conducted will permit immediate correct decisions to be made which can result in a successful new product, better sales, a wider market, an improved plant, and steady employment.

Small forest products industries seem to appreciate the advantages of applied research but their managements frequently contend that the expense of research is far beyond their capacity to pay. While this may be true of comprehensive fundamental research projects, it is not essentially true of applied research for which many facilities are available to the small plant—some requiring only personal application and time.

Small plant research is applied rather than fundamental research and involves many applications other than just the development of better waste utilization, new products and new processes. It should include economic research for business survival; materials and construction research for problems of assembled wood products; operations research, aptly described by John Tebbets at the Northeast Section meeting at Glens Falls in April 1955 as "research at the operating plant level"; marketing and market research; and motivational research at both plant and sales levels—to name just a few.

Marketing research is gathering, recording, analysis, and interpretation of all facts about problems relating to the transfer and sale of goods from producer to consumer. Market research is that part of the broader subject having to do with means and methods of measuring the extent of the market and determining its characteristics.

There is nothing magical about applied research. It involves recognizing the specific problem, finding the associated facts, and organizing them in such a way that sound conclusions can be drawn. It is important that the project gun-sights be lined up on a single bird rather than to attempt to bring down the whole flock. It is also important not to fence research in but to allow it to proceed where the facts lead.

Put Results to Work

To be effective, small plant research requires an understanding of proper scope, functions, values, applications, and possibilities of its use in attaining better management, product, and plant operation. The most important requirement is that management know how to put research results to work. Research is essentially a state of mind and for best results should be encouraged throughout the entire plant organization.

Small forest products industries will find a wealth of fundamental research results readily available in well organized form for application to specific problems directly affecting design and construction of product as well as seasoning, processing, machining, gluing, sanding, assembling, and finishing. Much of this material is available in published form, with subjects treated ranging from growing the forest to packaging and shipping the finished product. Extensive information and statistical data are also available for intelligent marketing and distribution analysis, as are reports on the financial aspects of the forest products industry and its specific branches, such as income, assets, liabilities, and profit per dollar of sales.

The place for the small manufacturer to begin his research efforts is in his own plant. Supervisors and workmen of the small plant are generally more versatile and closer to all the details and major problems than those of larger plants. They are frequently the source of ideas and when advised of specific problems usually can make valuable suggestions. Cost information of each specific part is required to be competitive and cost details on operations at every stage will not only show the profit potential but also need for change. Sales and production information provided by company records can indicate trends and changes.

Representatives of services, materials, machinery, and equipment manufacturers today are sales engineers rather than just salesmen. They have considerable knowledge of what is being done in other plants to solve similar problems and within the scope of their representation are usually well equipped to handle problems of a specific nature. Discounting a natural tendency to stress the superiority of their own products, their ideas can be most valuable. If you are fortunate enough to run into an expert, he is usually quite willing to let you pick his brains.

Catalogs and bulletins from these manufacturers can also provide much valuable information, some of which goes beyond specifications, price, and applications to bring in background

[1] Presented at meeting of FPRS Northeast Section Oct. 20–21, 1955, in New York City.

The Author: P. H. Graham, President and Editorial Director of Clinic of Wood, has more than years' experience in woodworking field. In FPRS, he has served as Membership and Publicity Chairman of the Northeast Section for several years.

material, basic engineering data, and research results. Trade associations of these manufacturers also provide reference service on specific equipment and its applications and specifications, and will frequently provide service for specific problems.

Trade and professional associations perform research of an applied nature to service problems submitted by association members and some fundamental research is conducted for the benefit of the entire membership. Most executive secretaries know their field thoroughly and lacking specific answers to questions submitted, can refer the problem to members or consultants specializing in the field of the problem. One of the most vital functions of these associations is the publication of results of research conducted in their respective fields.

There are associations in practically every branch of the forest products industry as well as associated materials or processes. A comprehensive listing of these associations may be found in the publication, National Associations of the United States, which may be obtained from the Supt. of Documents, U. S. Government Printing Office, Washington, D. C.

Wide Range of Information

Memberships in these associations provides the small plant with valuable information ranging from basic cost accounting procedure to sales, marketing, and distribution data. These associations also supply information and help to promote members' products to sales and user groups. Some of these associations also maintain separate research departments which are partially self-supporting.

One of these is the Timber Engineering Company, with a research laboratory in Washington, D.C., which expanded its facilities and functions during the past 11 years to perform extension forest products research work on a fee basis for individual companies, associations, and government agencies, and to conduct courses for instruction of plant personnel and inspectors in various fields, as well as serving its patron, the National Lumber Manufacturers' Association.

Teco's services are available and are being employed by small forest products manufacturers. While extensive and rather expensive research projects have been conducted by Teco, many applied research projects conducted for small plants have cost less than $1,000 per project.

Conferences and seminars sponsored by many of these associations are generally informal but highly productive of useful research information. They generally cover a lot of ground and some subjects discussed may not be relevant to either product or problem. Benefits from attendance at association meetings are usually commensurate with selection made of which should be attended.

FPRS Benefits

Leading in this method of dissemination of pertinent and up-to-date research information is our own Forest Products Research Society. At its meetings you are given an opportunity to question groups of experts or individuals who know their fields thoroughly, and have extensive practical experience and research backgrounds. A wealth of research information is also published in the FOREST PRODUCTS JOURNAL. Furthermore, an opportunity is provided to consult personally and informally with more experts and forest products industry authorities than in any other single group or association. FPRS Subject Matter Committees allow members to affiliate with one or more of thirteen diversified fields for the further interchange of information and advancement of technology through correspondence.

The most prolific and extensive research facilities available to the small manufacturer at moderate cost are provided in the form of government research carried on at national, regional, and state levels. The abundance of government research information has not been utilized to proper advantage principally because its existence and ramifications are so little known. The government has available for distribution at the price of a few postage stamps, or a few dollars at the most, valuable research data that is more complete and much more extensive than any single concern or research organization can ever hope to gather in original investigations of its own.

The first place to look for Government research sources is in the U. S. Government Organization Manual, prepared by the Federal Register Division, National Archives and Records Service, which is available from the Government Printing Office, Washington 25, D.C. for just $1.00. This is the official handbook of the Government covering creation, authority and functions of all branches of the government, with field offices, charts showing Government organization, departments, and major independent agencies, and describing in detail responsibilities, activities, and services performed for all Government departments, agencies, commissions, bureaus, and offices.

Military and civilian agencies of the government regularly publish a great deal of research information of both general and specialized nature directed as other information that is important to the forest products industry as well to anyone in any business. Guidance and help in general management and business is also available at a moderate cost.

For example, government business service bulletins are available on request classified as to specific product, or general classification of products, which provide pertinent reference information on design and manufacture, and help in determining the proper market and how to move the products into market channels.

Government agencies are available for direct problem consultation as well as general advice and maintain channels of information which will keep the small manufacturer up-to-date on research, technical developments, business conditions, industry sales, inventories, and other pertinent factors associated with the successful and profitable operation of his business.

Available Government Aid

Typical is the Small Business Administration established at the national level to stimulate the expansion of small business enterprises and the development of new products. It supplies many publications and special services designed to deal with the problems of small business, including financial assistance.

The Small Business Administration will continue to operate for at least the next two years by recent extension. Small business has had some trouble in obtaining venture capital from this agency in the past but this condition has improved. Small Business Administration loans made to businesses in flood disaster areas recently were life savers and this aid was also extended to home owners of these areas. A recent SBA service was the Products Assistance Program designed to assist small companies in keeping abreast of products and marketing developments. Another new program sponsored in cooperation with colleges and universities this year was management courses for owners of small businesses.

While by no means a complete description of all government agencies providing research facilities and reference information, the following cross-section listing is offered to provide an idea of the extent and diversification of government aid available to the small manufacturer of forest products at reasonable cost:

The Forest Service of the U.S. Department of Agriculture is the agency most closely identified with the forest products industry and its Forest Products Laboratory, established at Mad-

ison, Wis. in 1910, is its most versatile service agency. The Laboratory deals extensively with fundamental research, treating many problems of the forest products industry which are national in scope, and the industry has received many benefits from this activity.

This research has been responsible for much of our current knowledge about good forestry, logging, and lumbering practices; improved air seasoning and kiln drying; physical mechanical, and chemical properties of various wood species under different forest and regional conditions; preservative and other wood treatments to improve wood properties—to name a few of the many contributions.

The Forest Products Laboratory also serves as headquarters for exchange of information to coordinate research done independently by colleges and universities and conducts various courses of instruction for the industry. Specific projects are also conducted at the Laboratory for industry involving testing, technical development, and research. Another service not as generally known to or utilized by the small manufacturer provides, at a moderate fee and expense arrangement, services of top-ranking specialists and technologists as consultants on individual plant problems.

At the regional level are the Forest Experiment Stations which conduct both fundamental and applied research projects directed mainly toward local area problems. Research results are published to aid in the solution of these problems. The Forest Utilization Service, operating out of these stations, makes direct contact with forest products industries in the region and thus is able to provide valuable advisory and reference information. On-the-job availability of F.U.S. field men is especially attractive to the small manufacturer for personal discussion of his problems.

The Department of Commerce maintains a wide range of service agencies set up to deal with general and specific branches of every industry. Its field offices provide direct service at the regional level.

Its Business and Defense Services Administration provides an extensive information service, including research guides and summaries of information on specific subjects as well as marketing and business conditions. Its Office of Technical Services is directly concerned with research and issues regular research and technical reports listing results of current research efforts in all fields.

Its Office of Distribution is concerned with products, production, facilities, marketing and distribution, and publishes a monthly Distribution Data Guide of current information on these associated business subjects. Its office of Business Economics operates as a clearing house of business statistics and surveys of current business which include specific data on forest products, such as wholesale and retail price index, sales and inventories, production index, hours and earnings of production workers, etc.

The Bureau of Census is a prolific source of statistics required for intelligent marketing and distribution analysis as well as such other valuable reference data as industry reports, business patterns, employment and payrolls, etc. The Department of Labor provides consultant service for specific labor problems and will make available standards and valuable information on collective bargaining, employment, payrolls, labor turnover, hours and earnings, etc. for specific industries and industry divisions.

The Federal Reserve System Board of Governors supplies much valuable reference information on income and other factors influencing the demand for forest products. Financial aspects of the industry such as income, assets, liaibilities, and profits per dollar of sales are reported by the Federal Trade Commission and the Securities and Exchange Commission in their joint publication, "Quarterly Financial Report —United States Manufacturing Corporations". The Bureau of Foreign Commerce provides a service for export sales and shipment, implemented by an extensive world trade information service.

These are just a few of the many government agencies which can be mined for information that may be used in applied research by the small forest products industries. Many publications are distributed by the U. S. Government Printing Office, rather than by the individual agency, and are listed in the Monthly Catalog of United States Government Publications.

International Organization

Much valuable research information is also available from international organization publications reported by such groups as: International Documents Service, International Union of Forest Research Organizations, Food and Agriculture Organization of the United Nations, and Organization for European Economic Cooperation.

One of the most comprehensive reports published about forest products manufactured in the United States is the OEEC series, "The Timber Industry in the U. S. A.", reported by a group of visiting European experts.

Considerable forest products research information is usually available at the state level. State government reference material is influenced by local conditions and is generally directed toward the solution of state area problems. Many small manufacturers currently contact state commerce departments but neglect an agency which can give them considerable advice and aid.

This agency is the state planning and development commission which is maintained to render valuable service for the development of industry throughout the state. Although this agency is best known for bird-dogging in an effort to attract new industry into the state, one of its major objectives is to aid in product and market development for existing small business as well as to help in obtaining required financial assistance.

One of the best and most available research sources for the small manufacturer is the local area college or university. Most land-grant colleges and state universities maintain research agencies for the development of new and better methods of utilizing state forest resources. Dissemination of research results and pertinent technical information is one of their major purposes.

Most of their research is aimed squarely at local area problems and industry needs and close personal contact is made possible by their extension facilities. Extension courses not only provide special training for industry personnel but also serve to report latest developments in all fields of the forest products industry.

In addition to an extensive knowledge of local forest products industry problems, these colleges and universities have a great deal of background information. They maintain their own laboratories and research specialists and include on their staffs a number of highly competent technologists, many actively engaged in doing advanced research for industrial and governmental agencies. Small scale research conducted often contributes greatly to the development of new processes and products on a larger scale, sometimes reaching national or international importance. They are also acquainted with specialists in other areas and are well equipped to service practically any problem of small or large forest products industries.

Colleges and universities make their research publications available at modest cost and many rank as mapor contributions. Their specialized knowledge, talent, and research facilities are available to the small manufacturer at a moderate cost per project and general questions are frequently serviced without cost.

A valuable service to industry is also available from their bureaus of

business and economic research which provide consultant service and reports of general and local area business conditions, statistical business and market indicators, motivation research, operational research, and similar subjects.

Helpful Literature

Many good books are published on forest products research and associated subjects but small plant management often finds these time-consuming and reports that some subjects did not appear to be as current as desired.

This criticism was not made of trade magazines which depend upon timely balance of editorial features for advertising and circulation appeal. Many specialized publications are available which deal with a specific section of the forest products industry and treat individual types of business and products. Their editorial staffs also have a wide acquaintance with experts, readers making a similar product, and other sources of information to draw on to answer questions and requests for general background information.

It is possible for trade magazines to accumulate in such volume as to make it difficult to read them all efficiently. For the busy small plant executive, there are available various abstract reports and digests which provide him with a selection of top grade reading to permit the selection of articles appearing in current publications that he should read.

Consulting Services

Finally, the small manufacturer may obtain the services of an independent laboratory or consultant. If the problem is clearly defined, cost of either service need not be excessive. Expensive projects are usually brought about by the requirement of exhaustive preliminary study to discover the nature of the problem—not actual servicing of the problem.

The independent laboratory offers expert technical services in research, testing, and inspection of all types of products or processes. It serves to solve specific production problems, provide quality-control standards and procedure, improve or prescribe process or manufacturing procedure, or pioneer an original process or product. No problem of the small plant is too insignificant to receive its attention. Operating on a competitive basis, individual project charges of the independent laboratory are seldom excessive.

Consultant service is available to the small manufacturer on a specific project or regular interval basis to render the same service enjoyed by large plants which have their own engineering staffs. It may be provided by one of the larger consultant firms which carry a staff of specialists to provide service in many fields; the specialist who operates in a single field of experience, such as kiln drying, finishing, methods and time study; or the general consultant who provides general service and brings in specialists, if and when they are required. A rather different type of consultant service was recently introduced which operates by mail to service problems which do not require on-the-job participation.

How to Proceed

Where possible, the small manufacturer should avoid the expense of outside research service until he has gathered and analyzed data already available. His first investigation should be in his own plant, utilizing past experience, records, and suggestions of supervisory and plant personnel. Many answers will be found here.

This information can be augmented by quizzing visiting sales representatives, writing to suppliers, and discussing problems with manufacturers of similar products or those who operate with similar processes and equipment. Visits made to similar plant operations can also be productive of much valuable information.

Next would come collection and analysis of all data available which has already been accumulated and organized by government, trade and professional associations, trade magazines, books, colleges and universities, and other research organizations. A good reference to resource sources is provided by the Forest Products Research Guide in Fundamental and Applied Research published by the NLMA Committee on Research and Product Development.

If the answer has not been found after all possibilities of these sources have been exhausted, then is the time to obtain outside research service. By this time the actual problem should be pretty well resolved so that the amount of outside service required is well defined and limited in scope to eliminate the cost of preliminary investigation.

Unfortunately this procedure is so time-consuming that many manufacturers find it more economical to call on outside research service for those problems which require immediate attention. Digging out already existing data is a tedious and slow job at best, and careful analysis and drawing correct conclusions require experienced judgment.

Procuring the best advice obtainable as soon as possible is usually the most economical course in the end. Few problems of the small plant will require service beyond its capacity to pay. In most cases, payment for research service is quickly amortized by savings made possible.

Where a single research project involves problems common to other plants, cooperative research in which cost is shared becomes a feasible means of lowering overall expense of research. This plan has been quite succesful in many applications. In some instances it has led to an integrated utilization program which has proved very profitable for cooperating members.

Research to be effective must discover trends and changes as trends and changes are far more important than are conditions at a given time. Small forest products industries have the power to work out of their trials and difficulties when backed by the knowledge and proper application of available research facilities.

Wood—The Future Chemical Raw Material[1]

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All trends indicate a bright future for wood as a chemical raw material. The integration of forest products industries is becoming a reality. By-products are being recovered from pulp residues and extractives from bark, fiberboards and particle boards are being produced from wood residues, and chemicals from wood are already on the market. Further research and development will pave the way for complete utilization of forest material.

WOOD, A RENEWABLE RESOURCE, has a brilliant future as a raw material for the chemical industry. Every indicator of trends points in that direction—availability of raw material, estimates of future needs, and the explorations of research at the U. S. Forest Products Laboratory and elsewhere.

As a result of conventional wood processing, over 100 million tons of residues become available every year. Logging operations leave 50 million tons of raw material in the woods to rot or be destroyed by slash fires. Primary manufacturing—lumber, plywood products—produces 45 million tons of residue annually. The pulp and paper industry has 9 million tons of organic material available in its spent liquors.

The least costly raw material for chemical processing is that resulting from primary and secondary manufacturing. The costs of collection and transportation to the processing site have been paid. However, 63 per cent of this material is used as fuel and so must bear the charge of replacement fuels if otherwise used. In many localities the slabs, edgings, and trim which are chippable are sold to pulp mills and structural fiberboard plants, but the total quantity as a percentage of that available is not great.

Unfortunately, the logging residues and cull trees in stands being cut can only be collected and brought to a processing plant that is equipped to make integrated multiple use of the material. The pulp residues of kraft mills are burned in order to recover the pulping chemicals and provide process steam. To the sulfite mills, however, this residue has presented a serious stream pollution problem, and many millions of dollars have been spent to find less harmful ways of disposing of it.

Integration Essential

When all the forest land of the United States has been placed under intensive management, the total quantity of raw material available for chemical processing should be more than doubled by the harvesting of thinnings and cull trees. It is hardly conceivable that economic forest management of the intensity visualized for the future will permit the growing of timber for only one merchantable product. Mixed species and the unsuitability of some thinnings, as well as tops and limbs, for conventional products will necessitate the planning of an integrated forest economy.

The integration of the forest industry of the future must include not only the integration of the processing plants with the products produced by the forest; these plants must also be integrated among themselves. We will not in the foreseeable future grind up all the wood grown and reform it into merchantable products. We must still continue to produce lumber, veneer and plywood, poles and piling, and other products of natural wood. We must look to the residues or by-products of these manufacturing operations for the raw material for a chemical industry. This raw material must be available at the lowest cost possible in order to compete with the synthetic chemical industry based upon petroleum.

Chemically, wood substance is generally considered to be made up of three components—extractives, fiber, and lignin. Since the amount and composition of the extractives will depend upon the species of wood, any detailed discussion is omitted at this time. The fiber fraction, which comprises about 70 per cent of the wood, is made up of two fractions — hemicellulose 20 per cent and cellulose 50 per cent. The lignin component constitutes about 30 per cent of the tree.

The most fruitful utilization of wood by a chemical process to date has been the conversion of the cellulose to pulp. This industry ranks fifth among the nation's top industries (1).[3] United States production last year rose to 26.7 million tons valued at $8,738 billion. About 170 different types of pulp products are made, and we have reached the highest per capita consumption of paper and paper board in the world—384 pounds, requiring approximately 800 pounds of wood, for each individual. The pulp and paper industry has far from reached a peak and in the next 20 years will approximately double in size.

The pulp and paper industry has been slow to utilize the hemicellulose fraction of wood removed in processing. In the kraft pulping process this easily hydrolyzable portion of the fiber has been converted to saccharinic acids, which in turn are evaporated and converted to heat. The sulfite pulping process converts the hemicellulose material to free sugars, about 400 pounds for each ton of pulp produced, and these have been the major cause of stream pollution by removing oxygen from the streams (6). In a few plants this liquor is burned for fuel.

Two plants in this country are converting these sugars to yeast, and one is fermenting the hexose sugars to industrial alcohol. One of the important pulping processes that appears to have a bright future is the prehydrolysis sulfate. Hardwoods are very satisfactorily processed for chemical pulps by this method, and the sugars from the hemicellulose fraction are available for processing to chemicals.

The major chemical derived by acid conversion of the pentose fraction is furfural. One company has been reported to have at least reached the pilot-plant stage. Furfural consumption in the United States exceeds furfural production at the present

[1] Presented at meeting of FPRS Northeast Section Oct. 20–21, 1955, in New York City.
[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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[3] Numbers in parentheses refer to literature cited.

time. The major portion of it is converted to nylon. Other uses for furfural include petroleum refining, solvent extraction, and synthetic resin manufacture. The current production of furfural in the United States is more than 100 million pounds per year. In the next five years, four times this amount will be consumed if available.

The raw material now used for furfural in the United States is principally corncobs. Practically all of the cobs that can be economically collected and processed to furfural are being used. No raw material other than wood is available in sufficient quantity to meet foreseeable requirements. Hardwoods, which yield more pentose sugars than softwoods, constitute the chief remaining raw material available for this important organic chemical.

Future of Pentose Sugars

The use of pentose sugars by the chemical industry in the years ahead will be great. One possible method of utilization will be by biochemical processes. At present, few organisms are known that can consume pentose sugars. This should prove to be a fertile field of research. Bioengineering, the combination of biochemistry and chemical engineering, is in its infancy and should have a brilliant future. Hardwood hemicelluloses consist approximately two-thirds of pentose and one-third of hexose sugars, while in the softwoods less than half the total sugars are pentose.

The hexose sugars, which are obtained from the true cellulose fraction, have potentially great usefulness although this portion of the wood is difficult to hydrolyze.

Acid hydrolysis of the cellulose fraction of wood results in sugar solutions that are 80 to 95 per cent hexose, the remainder pentose. Solutions of these sugars can now be prepared by the dilute sulfuric acid process for about 4 cents a pound in a solution evaporated to 45 per cent sugar content (2). If the dilute solution, 6 per cent as it comes from the processing equipment, can be used, the sugar cost would be about 2 cents a pound.

One of the major possibilities of glucose utilization in the future should be as food. With the prediction by many marketing experts that the population increase in the United States will take care of the present agricultural surpluses, glucose (corn sugar) should be a profitable product from wood.

Chemically, the hexose sugars are a highly interesting product. The literature is full of uses for them. One of the most interesting reactions is the continued acid decomposition of hexose sugars to hydroxymethylfurfural and then to levulinic and formic acids (6). Hydroxymethylfurfural, when available in commercial quantity, should prove to be an even more interesting material than furfural as an organic intermediate. Levulinic acid, likewise a double-ended molecule, should be an important raw material in the years ahead, particularly in the synthetic fiber industry. At present its only use is in pharmaceuticals; produced in pilot-plant sized equipment, it sells for approximately $5 a pound.

The hexose sugars found in wood can be hydrogenated to polyols—sorbital, propylene and ethylene glycols, erythritol, and glycerine. One large commercial plant produces sorbitol from pure glucose for use as a humectant and plasticizer. The further reaction of sorbitol with hydrogen splits the molecule into the glycols and glycerine or erythritol. The hexose sugars can be converted by fermentation to glycerine and other polyols, such as arabitol and erythritol. We believe this process is only a few years away from commercialization.

Outlook for Lignin

The great unknown in wood chemistry or wood utilization is lignin. This substance has proved an enigma for several generations. Its main building block is a substituted phenyl propane. How these building blocks are put together or how lignin is combined with the cellulose is still unknown. At present, all lignins available are derived from a pulping process that yields the fiber portion of the wood as the primary product. This leaves the lignin in variously degraded or polymerized forms.

Lignin is a potential source of aromatic chemicals. Two methods of processing are possible. One would be a controlled pyrolysis in which the lignin would be decomposed by heat under conditions calculated to give the greatest yields of merchantable aromatics in the tars, with an activated char as the residual product. The approach to this appears to be a fluidized bed process, but only a slight amount of research has been carried out.

The other method of utilizing lignin appears to be a catalytic hydrogenolysis. Experiments with this process indicate that lignin should be an excellent source of phenols, cyclohexanols, and substituted cyclohexanols.

The research needed if we are to completely utilize wood as a chemical raw material must involve the separation of wood into its three main components—hemicellulose, cellulose, and lignin—with as little change to each as possible.

We are relatively confident that we can remove the hemicelluloses by a mild prehydrolysis with little effect upon the lignocellulose residue left. How to separate the cellulose and the lignin without seriously modifying the lignin is a major problem. There have been many approaches to this. We believe now the proper approach is one based on the philosophy that the effect of the separation upon the cellulose should be ignored. Lignin is the material we need to separate and recover in a marketable condition. The largest use for lignin obtained with a minimum of processing appears to be in plastics and molding compounds. A lignin must be obtained that has flow properties and other characteristics that contribute to the final plastic product. Many lignin plastics have been made but none have been too useful.

One product of wood that is obtained in sizeable quantities when it is being processed for chemicals is acetic acid. By the acid degradation of wood, approximately the following amounts of products per 100 pounds of dry wood result: acetic acid, 5 pounds; formic acid, 4 pounds; levulinic acid, 14 pounds; furfural, 7 pounds; and lignin, 30 pounds.

Research Approaches

Several radically different approaches to the chemical utilization of wood have been investigated on a limited scale at the U.S. Forest Products Laboratory. Grinding in a small laboratory ball mill has converted wood to a form so fine that it is nearly water soluble. Its hydrolysis rate has been increased manyfold.

Cellulose has been subjected to the action of high energy cathode rays (4). The degree of polymerization of the glucose molecular chain has been lowered to about 200 and the material approaches water solubility. The threshold energy required for this reaction is 5×10^8 roentgens. This amount of energy appears to be slightly in excess of what would be commercially feasible at this time. Energy equivalent to 5×10^7 roentgens will speed up the hydrolysis of the cellulose 17 times. At the same time, maximum sugar yield has been increased threefold. This amount of energy does not appear too remote from practicality. Little has been done on the effect of the enzyme cellulase in separating wood into its various chemical compounds. This method may prove to be of commercial importance in the future.

We know that ultrasonic energy has been used to degrade material and should prove a fertile field of research. Wood irradiated in atomic piles is

still only a laboratory curiosity. It is difficult to foresee what effects atomic radiation may have. The possibilities, as we move into the atomic age, should not be overlooked.

Present Problems

The more immediate problems confronting us, however, revolve about the use of chemical processes to round out the utilization of our forest material. Chemical processing must be treated as a scavenger operation after the wood grown in the forest has been processed by physical means to as many useful products as possible. Besides the usual products, there are composite products, including combinations of paper, hardboard, particle board, lumber, insulating fiberboards, and veneer. We have not begun to combine chemicals and wood or wood products to the maximum degree possible.

The resin-impregnated paper honeycomb industry has begun with three companies in production (3, 5). Veneer is combined with paper overlays by approximately six manufacturers. Paper-overlaid lumber shows great promise in improving the usefulness of wood. Market potentials of particle boards have only been scratched; significantly, their cost is affected more by that of the chemical binder than by the cost of the wood. New and less expensive binding agents are needed.

One of the major problems always confronting the user of wood is its lack of dimensional stability. The Forest Products Laboratory has developed one method of dimensionally stabilizing wood whereby shrinking and swelling may be reduced 60 per cent. By this method, veneers treated with 30 per cent of their weight of phenolic resin are laminated together to attain the size of material required. This product, impreg, is now in commercial production by two companies. It is being used by the automobile industry for patterns and die models. But this product is expensive and hence is economical only for high-value purposes.

One other method of stabilizing wood has been developed by the Forest Products Laboratory that shows promise of being sufficiently economical to use with wood going into general millwork. The veneer is treated with a 2 per cent solution of formaldehyde in the presence of a mineral acid catalyst, and the cellulose chains are cross-linked by the formaldehyde. While the wood is stabilized, its strength is definitely impaired by the hydrolysis effect of the mineral acid. Eventually a catalyst that causes the cross linking of cellulose chains without damaging the wood structure will be found. An attempt was made to use atomic radiation for this purpose, but it did not prove satisfactory.

Major Stimulant

One major mechanical development in the past 10 years has done more to stimulate chemical utilization of wood residues than anything else. The whole log barker, either hydraulic or mechanical, now makes possible a separation of bark and wood prior to the breakdown of the log. We now have several pulp mills that are dependent entirely upon chips from sawmills for their raw material. One mill in particular has no wood room. In the sawmills of the Pacific Northwest, there are more than 200 chipping installations.

The availability of the bark brings us back to the subject of extractives, since a major portion of the extractives in a tree is located in the bark. For example, about three-fourths of lodgepole pine bark is soluble in dilute alkali. In general, between 2 and 20 per cent of the wood substance itself, depending upon species, consists of extractives soluble in neutral solvents. These, of course, have been the basis of the naval stores industry. Old-growth longleaf and slash pine stumps are getting to be in short supply, and this industry is increasingly dependent upon gum naval stores and upon the tall oil recovered from southern pine kraft liquors.

Extractives in wood and bark include water-soluble products, such as carbohydrates, organic acids, tannins, and dyes, as well as fats, oils, waxes, resins, terpenes, and essential oils. Some of these products are important and the operations profitable, but in most cases the volume is small. Now that bark is being separated from wood, this industry should become more prominent. Two companies now have sizeable operations in which an oil well drilling mud additive is manufactured. Several companies have extensive research projects, which should lead to further expansion of the recovery of the extractives.

Conclusions

The concept of integration of the forest products industries is not just an idle subject of conjecture. It is becoming a reality. We have made a start, small at this time, but a slowly developing chemical industry is on the horizon.

Sawmills have built pulp mills, which have gone on in turn to recover by-products from pulp residues. Pulp companies have put in chemical plants to recover extractives from bark. Conversely, we have seen pulp mills build sawmills and veneer plants. Wood processing companies have built structural fiberboard and particle board plants to use their residues. Many sawmill companies have active tree farm programs in order to stabilize their raw material supply. Such things as silvichemicals are now on the market.

The next 10 years should see a major advance in the use of wood as a chemical raw material at plants integrated with conventional wood-processing mills. In the laboratory we know how to take wood apart; but engineering development is needed.

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Discussion

W. B. Wilkins (Consulting Engineer): You got close to home when you said they were making some fillers for the plastic field. Often when you think of fillers, you think of materials they put into plastic material to cheapen it. I don't think that this is necessarily true because this filler, up to a certain percentage, will really complement the physical properties of most of the plastics, with the exception of the dielectrics.

Mr. Smith (General Electric Co.): The question I have is not directly chemical utilization but I think it's related. There has been a lot of work done in developing and promoting hardboards and particle boards. But is there any chance that that would be promoted to the extent that there would not be that much residue that will be utilized, and that in order to get these materials, we might have to be using good pulp material? Is there any danger of one thing competing with the other?

Dr. Locke: As far as the raw material is concerned? I see no serious competition there. The companies which are manufacturing particle board are those who want to further manufacture their own raw material. They are

not in a position to put in a pulp mill for they do not have sufficient residue or capital available. Also, for particle boards the raw material generally is unsuitable to the paper industry—shavings, sawdust, things of that nature. Sawdust does not have too important a position because of the fineness of particles and the cost of the resin. As the particle size goes down, the resin content must increase.

For hardboard, a good quality of fiber is required since to obtain the required strength property the material must be capable of forming a mat either felted from a water slurry or from air. Hardboad uses what might be termed a whole wood fiber. The plants are smaller, require less capital investment, and can be integrated with sawmills and veneer plants. Hardboards have a definite place in the wood utilization program. The tonnage in relation to pulp for paper or chemical conversion will always be small. No, I see no dangerous competition for raw material.

Mr. Wilkins: What particle board seems the most promising?

Dr. Locke: You are probably familiar with the work which Dale Turner did at the Forest Products Laboratory on flakes. We obtained strengths that approach the strength of plywood. We have run into other properties because of the random orientation of the flakes, which gave us additional advantages. For structural material the flake board has the best future. On the other hand, the market seems to be absorbing core particle boards very rapidly. I think that is understandable when one compares the cost of such a core material with glued-up lumber core. The furniture companies tell me lumber core costs between $130 to $260 ready for the cross banding.

Mr. Grant (General Electric Co.): Along the line of hardboards, isn't the low cost of particle boards due to the fact that they're using residue or the unusable parts of the logs? Now suppose that the demand became so great they had to chop up good wood. Would the cost then go up so that they wouldn't be able to compete?

Dr. Locke: The ability to compete depends upon the product manufactured and other manufacturing and distribution costs. In general I would say they couldn't afford to go out in the woods and bring material in for that purpose alone, although a few companies are. The best way would be to put woods material through a primary breakdown plant, take the high priced sound wood out and use it as wood. This procedure would develop more residue. From the available residue, about 50 million tons of particle board could be manufactured each year from the raw material available. That is quite a sizeable production.

Mr. Wilkins: I think there is probably another angle on that, too, that there is a lot of wood coming out now that has a small yield of high grade wood in it that is not being used. It doesn't pay to cut it. The use of some for particle board might enhance values and make it possible to work with smaller yields of the high grades.

L. R. Louis (Bramco, Inc.): On particle board, most of this comes $25 a cord.

Mr. Wilkins: Can you tell us anything on the possibilities of bleached semichemical pulp?

Dr. Locke: Semichemical pulp is the most rapidly expanding product of the pulp and paper industry. The curve in the last 10 years is almost vertical. Most of that increase has been because neutral sulfite semichemical pulp has become the standard for corrugating board. The new uses and the flat crush test have made that product preferable. It is an unbleached product and the yields are around 75 per cent. The neutral sulfite semichemical pulp from hardwoods can be bleached. The yield of bleached material is 50 to 60 per cent against the normal conventional pulping yield of about 40 per cent. This material will hydrate and form into a sheet with much less mechanical work than will conventional pulp. What are the markets? It makes a strong pulp and has a very bright future in tissues, printing papers, and other white papers. We now have mills producing these. We think at the Forest Products Laboratory that the bleached semichemical pulps, while they use more chlorine, have a very important future.

A Look Ahead in Northeastern Sawmilling[1]

FRED C. SIMMONS

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Current developments and prospects for the immediate future in Northeastern sawmilling are discussed, with a projection regarding the place of the sawmill in the atomic age. Sawmills of the future will be wood-conversion plants, producing accurately sized, properly seasoned lumber, plus a steady flow of raw materials for pulp and chemical uses.

TODAY WE HAVE INDUSTRIAL PROCESSES and products that none of us dreamed of 20 years ago. Not too many years ago we would have looked upon the atom-powered submarine as a bit of fantastic science fiction. Developments have come so fast that we cannot foresee what the picture will include 20 years from now.

What about wood in that picture? And specifically, what will the sawmills—one of our biggest wood converters—look like when the atom is our chief source of energy? Will we be using electronic rays to cut boards out of a log? Will we have sawmills at all?

Strange new developments of this sort are possible; but in my opinion they are not probable in the foreseeable future. Traditionally, sawmills have changed slowly. And the pattern of change is such that I cannot visualize a system for making boards and timbers from logs that will not be an extension of present practices.

Let us look then at the current developments in our Northeastern industry and at the immediate future. Then we can venture to look a little further ahead.

We have lost most of our larger mills simply because the bulk of our virgin timber has been cut. It hasn't been possible to keep a big mill going with odd lots of logs gleaned over a large area on more nearly a sustained-yield basis. Consequently, the small mill and the medium-sized mill are

[1] Presented at meeting of FPRS Northeast Section Oct. 20–21, 1955, in New York City.

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turning out a larger proportion of the region's lumber production every year.

These sawmills operate under great pressure of competition. In recent years the Northeastern sawmill operator has been confronted with rapidly rising costs (especially for labor) and a market that will not stand for much more of an increase in the price of his major product—lumber. Hence the mill man is under constant pressure to hold his costs down as well as to increase his volume of marketable products.

Total lumber production in the region has held up very well. It has even increased in recent years. The trend is in the direction of greater rather than less efficiency, with mill capacity adjusted to timber supply.

These trends in operating costs and supply of raw material have brought about new developments in all the aspects of sawmilling. And I believe that even more sweeping changes are on the way.

Sawmills Becoming Permanently Located

Some of these changes are already taking place without notice by many people, including a large number of those in the industry. The small portable sawmill cannot compete under today's conditions in the Northeast. Consequently, this is no longer a region of portable mills.

We estimate that in New England, 82 per cent of the mills (producing 84 per cent of the total volume) are permanently located. In the Middle Atlantic States, 72 percent of the mills (producing 71 per cent of the volume) are permanent.

One of the biggest reasons for this fundamental change is the desire of the mill labor to live in town and lead normal family lives. Not many workers are satisfied these days to live in a tarpaper shack in the woods and to move every few months. The portable mill is also basically inefficient, requiring a large amount of manpower per thousand feet of lumber output. Another reason, undoubtedly, is that there are not many big lots of timber available for sale on a clear-cutting basis; so there is less opportunity to find a set that will keep a mill going for more than a few months. Also, good road systems make it possible to haul logs farther to a mill.

This development is bringing about basic changes. For instance, when a sawmill operator settles down in a permanent location, there are pressures on him right away to improve and expand his facilities. To begin with, he can see the sense in putting better and more permanent foundations under his mill, and a building around it. That results in more and better-cut lumber. His neighbors come to him for bills of building materials and for lumber for their do-it-yourself activities. So he is quite apt to install a planer or moulder. About a third of our New England mills and a fourth of those in the Middle Atlantic States have already done just that. And as he develops a local trade he finds he needs better seasoning; so a good air-seasoning yard or even a dry kiln is a next step.

Waste Into Byproducts

Also, in his more accessible and stable location, he is apt to find that he now has more profitable opportunities to dispose of his mill waste. Hardwood mills particularly can work up a market for their slabs as fuelwood. Currently 80 per cent of the hardwood slabs produced in New England mills are being sold for this purpose. If he is in a dairy cattle or chicken-raising area, he may find that a demand for his sawdust and shavings for cattle bedding and poultry litter—particularly during the winter months—will develop. So he will erect a bin from which these products can be rapidly loaded into the farmer's waiting truck. Many millmen are now paying their bill for diesel fuel or electric power from the sale of sawdust.

Now a new and potentially tremendous market for chips to be made from slabs and edgings is opening up for the sawmill man at the region's pulpmills and wood-particle board plants. Although debarking to produce bark-free chips has been a problem, a solution is in sight. Until recently, log debarkers suitable for sawmill use cost $50,000 and up—too high a cost for most Northeastern mills. Now, however, there are two or three good debarkers on the market that can be installed for $25,000 or less. Three have been installed at northern New England softwood mills. We have heard that at least six more have been ordered by other millmen. Hardwoods as well as softwoods have been successfully debarked in the machines already installed, in winter as well as in summer.

A debarker in this price class is not out of the range of mills that saw 10,000 board feet per day. Its use not only makes the slabs and edgings salable as pulp chips, but also the debarking of the logs removes the dirt and grit in the bark. Consequently, saws stay sharp longer, and dogging on the carriage is apt to be easier and surer. This means lower maintenance costs, more accurate sawing, and better yields. The Redwood Association figures that debarking makes logs worth $7.50 more a thousand to their members, even though no slabs are sold.

Profitable markets for byproducts (we will no longer call the waste) frequently mean that the mill owner will be able to afford to haul his logs, even including the lower grade ones, longer distances. Improvements in public roads and better trucking equipment help out with this. Consequently, he has an opportunity to increase his daily production.

Currently the average full-time mill in New England (not operated as a sideline to farming or some other business) saws about 800,000 board feet a year, or 4,000 feet a day for about 200 days. I confidently expect to see this build up during the next few years so that the average New England commercial mill will saw between 10,000 and 20,000 board feet a day. I think this increase in average production will be a result of both fewer mills and greater total production.

New Equipment Available

Advanced machinery now developed makes it possible for the Northeastern sawmill to produce more and better lumber with the same or even a smaller crew, and at the same time make other salable products. Most of these devices are available in sizes and at prices that make them adaptable to mills that saw as little as 10,000 feet a day.

Some of this equipment has already been installed at Northeastern mills. We see many improvements such as mechanized log decks. These have chain conveyors installed in them that enable the sawyer to bring his logs forward and to load and turn them on the carriage automatically. We see automatic dogs, usually either air or hydraulically operated, that can be controlled either from the sawyer's position or by the setter on the carriage. Such devices make log delivery and dogging much faster, and at the same time surer, than could ever be done manually. The mechanical dogs exert a continuous pressure on the points, which insures against their loosening as the log is sawed.

We have not seen in the Northeastern mills many automatic sawyer-operated setworks, automatic offbearers, or automatic edger feeders. Such devices are now on the market, in sizes and at prices adapted to the Northeastern scale of operation. The performance of electronic setworks (in operation on small West Coast mills) is quite impressive. The sawyer has either a dial or a set of push buttons in front of him. As one cut is being made, he either sets the dial or pushes the button for the depth of the next

cut desired, and when the carriage recedes clear of the saw, the knees automatically and instantaneously advance just that amount, no more and no less.

Automatic taper setouts that can be sawyer-controlled are also available. Sawyers who operate this equipment say that it is no harder on them than operating the feed lever and signalling to the deck men, the setter, and the doggers; and, in addition, it is much surer with less chance of misunderstanding and mixup.

Other improved mill machines are available and are used to some extent. Among them are: shadow-line guides for edgers (these show the line each saw will cut, the full length of the board); electronically controlled edgers and trimmers; and automatic slab saws (those that convert slabs and edgings into pulpwood or fuelwood lengths with a minimum of attention).

Conveyor systems for products and residues and mechanized yard handling facilities are well developed and in common use in the Northeast.

New Types of Mills

Looking ahead, I believe the trend of modernization is not in a radical direction. Far into the future, I believe, lumber will still be produced in a type of circular or band mill now known to us, with the log dogged to a carriage. This type of mill is ideally adapted to the type of logs and markets with which we will have to deal for many years. Fundamentally, it is soundly conceived and well engineered. We can turn the log when we wish, taper-saw when we want to, and recover the maximum volume of high-grade material. We can "hog saw" low-grade logs or low-grade heart centers when we want to, or square them up as ties or timbers if that is desirable.

There is a place for, and a trend toward, a greater number of specialized types of mills for special types of sawing. Eleven sash gang mills (all but two of them made in Germany) today are installed in this section of the country. These are highly accurate, reasonably productive, and foolproof mills. For converting certain types of logs into standard-size material where grade is not a consideration, they are hard to beat.

There is also a field for gang and twin circular mills for much the same type of use. These will be used mostly as portable units in remote areas. The production rate is high, but as now built they are less accurate and more wasteful than the sash gangs. They have a place in the picture, though.

All of the gang mills have one major disadvantage—they saw parallel to the heart, rather than the bark; and consequently they sacrifice on grade and produce much cross-grained material. Although this is not serious in a number of applications, it is an undesirable characteristic for many uses.

The short-log bolter, another specialized type of mill with wide application possibilities, solves the taper problem. When used properly, it automatically taper-saws every piece. This is particularly important for many of our hardwoods like birch, beech, and maple, where the sapwood has a different value than the heartwood, and the two types of wood have significantly different technical properties.

Because a bolter rig can handle short lengths, most of the effect of sweep and crook present in so many of our small hardwoods is eliminated. Consequently, yield of tree and utility of product is increased. It is a fast machine when operated properly, and can turn out as much as 7,000 board feet a day, with two men. Few long-log mills can show such a productivity per man-day. The bolter will find its place handling logs less than 6 feet long and smaller than 17 inches in diameter.

The Mill of the Future

The mill of the future may look something like this:

It will be a permanently located medium-size mill, sawing 10,000 to 20,000 board feet of lumber a day, drawing logs from a radius of perhaps as much as 100 miles. The sawmill itself will be operated by no more than 4 or 5 men. Less physical effort will be required of the crew, but they will have to be smarter.

At most softwood mills and many hardwood mills, the first man will operate the log debarker. The sawyer will have controls at his position to operate the deck, the log stop and loader, the dogs, and do the setting, as well as feed the carriage.

The edgerman will also have a stationary position, depending on a pushbutton-controlled automatic offbearer and feeder to bring the lumber to the edger table or to send it directly down the rolls to the back end of the mill. He will control the saws in the edger electronically, depending on a shadow-line guide light to show him how to get maximum grade and yield.

The trimmerman will also operate an electronically controlled machine, and automatic mechanized conveyor equipment will do most of the sorting. Finally, there will be one or more automatic stackers and loaders, probably controlled by another man. There will, of course, have to be millwrights to keep all the equipment in running order. However, this type of work, demanding specialized skills, will probably be handled by outside specialists who serve a number of separate mills.

In conjunction with such mills there will be an increasing number of auxiliary installations to carry the processing one or more steps further, and to make the various products more salable. Slabs and edgings will be considered as primary products and will be processed to go to pulp mills, board plants, or wood-chemical plants that draw on a number of installations. Some sawmills may continue to make charcoal themselves, and some slabs may still be sold directly for home fuel.

Bark and sawdust will be sold as bedding and soil improver or the sawdust will be fed through hammermills to be converted into more specialized and higher priced products such as wood flour and polishing compounds. The lower and less profitable grades of lumber will be worked up into timbers or blocking, dimension, or cut stock; or they may be fabricated into pallets or other items, depending on the species being handled and on the local markets. Much of the lower grade lumber, particularly hardwoods, will find its way into chips for the pulpmills and chemical plants.

Many installations will have alternate types of head rigs for most efficient processing of the various grades of logs or bolts.

The end result will be accurately sized, properly seasoned lumber at competitive prices, plus a steady flow of pulp and chemical wood. Every bit of material delivered will be properly used. Our sawmills will be wood-conversion plants, and not merely sawmills as we know them.

As I said at the outset, it is difficult to think in any realm not related to the possible, as judged by past and current developments. I believe we will indefinitely use wood in quantity in the form we now know it. If I were to predict the future on a radically changed pattern, I would probably eliminate the sawmill. So the "future" in this paper is the time until developments in other lines bring us to that point. I think my prognostication will hold as long as we need sawmills. After that, I'm out of my field.

Discussion

Chester Babcock (Babcock Machinery Co.): These small mills that only have about 3 to 5,000 feet production per day, to get a return on their investment, can't afford to put in much expensive automatic machinery. I notice that there is a tendency now to

build up concentration yards. These small mills will saw up the boards, may edge them, bring them into 4-by 4-foot packages that can be handled by straddle carrier or fork lift, then load these on a truck and take them to concentration yards where a trimmer is installed. An up-to-date trimmer will trim about 40 pieces per minute. Running through that one trimmer, they can rig up the trimmer so that at the outfeed end, the lumber can also be graded and be ready for the planer or go to the customer. Will you please discuss concentration yards.

Mr. Simmons: I agree with you. One common problem of the small mill is that with the variety of species that they have to handle, particularly in hardwoods, and the variety of grades, including special grades such as piano action stock, the small mill just can't afford to sort to the best advantage, as the larger mill can. There are too many piles stretched out too far; the piles deteriorate too much in the process of building up. They will sit there for hours or days at a time before more lumber is put on them. So the small mill is up against it in sorting and marketing the stuff to hit the good markets which exist. The concentration yard has acquired a bad name in the Southeast for keeping the small mill operator ground down all the time by the low prices they pay. However, in hardwood production particularly, there is a place for such a yard. Recently we talked with a young Penn State graduate who wanted to start a concentration yard to pick up stuff coming out of the Eastern Shore in Southern Maryland, sort it, grade it, and perhaps do some remanufacturing on it. Basically, this is a sound idea. A good many of these manufacturing processes can be more economically run on a larger scale.

But, I do believe that Northeastern mills are going to increase in size partly because our regional cut is going to keep on increasing. We have many good second-growth stands that are just coming up into sawlog size. Regionwide, we are only producing 7 per cent of the nation's lumber cut. We have 15 per cent of the nation's forest area. We have been cutting in some of our areas for 300 years. As time goes on, our average tree size is increasing and the size of our average mill will increase. So the concentration yard will be less necessary.

Mr. B. Christian (Chicago Mill & Lumber Co.): You mentioned that $7.50 per thousand would be the increased value of debarked redwood logs. How would that compare, percentage-wise, with expensive hardwood in the North.

Mr. Simmons: I think that figure would be a little high for hardwood. Redwood bark, as you know, is very tough and stringy. Probably we ought to try to figure out more exactly what debarking would mean in increased value for hardwood. I wouldn't expect it to be so high, but estimate it might be between $4 and $5.

R. D. Carpenter (Reisen Hardwood Lumber Co.): We worked that out at Memphis several years ago and obtained a figure of $5.50.

Mr. Christian: What was your log cost? What was the $5.50 based on?

Mr. Carpenter: It was per thousand feet of logs sawed. Logs were up around $55 or $60 at that time.

R. I. Solow (Keller Products Co.): How portable will these new, larger, and more stable mills, with the heavy electronic equipment, be?

Mr. Simmons: The portable trailer-mounted mill, or the mobile mill, is another specialized type mill which definitely does have a place in the picture. But I think that that place is going to be, and should be confined to custom sawing for the individual farmer. When the farmer needs some lumber he'll get some logs from his own woodlot and bring them to the roadside instead of picking them up and hauling them to an established mill. The trailer-mounted unit would then come out and saw them. The farmer would thus be sure that he got all and only the products of his own logs. He also would have the slabs, edgings, and sawdust for whatever use he wanted to make of them. This is the place for the portable mill—not in commercial lumber production. The trailer-mounted mill is a good accurate mill, as it is now put out. It was probably the first sawmill to go to ball bearings. The permanently located, small, commercial mill is generally more efficient and better able to market its products, including residues.

Mr. Solow: Do you think mobile mills will be much improved over the mills of today?

Mr. Simmons: Yes, I think they will be. The current mobile mill is priced at about $3,200, about ready to go, which is a high price as compared to the majority of our small mills. This is due primarily to the number of ball and roller bearings installed in it. It is a good mill and is still being improved. Recently one manufacturer came out with a hydraulic feedworks for his mobile mill.

Mr. Babcock: The railroads now pile logs in certain locations. They have a railroad car with a sizing saw and an edger. They make ties on the car and dump them wherever they want them, instead of bringing everything into one point and having the extra hauling charge.

Mr. Carpenter: I don't like to have the concentration yard tossed so easily. We are more or less of a concentration yard, although we call ourselves a hardwood lumber company. But to go back to Mr. Babcock's comment, we take hardwood lumber in from small mills. We get about two million feet a year from New Hampshire to North Carolina. This is put over a Canadian trimmer. We grade it at the head end rather than the output end because we want the grader to have control over the cutoffs rather than the trimmer operator. We're asking our mills to cut logs a little longer because in the manufacturing process we double end trim the lumber. You sometimes get a little end checking when it goes through the air drying yard and the kiln drying process. So if you're going to come out at the finish with nominal length lumber, you want a little bit extra. Our trimmer saws are set to take care of a 12′ 5″ board in order to give good square end trim product. Of course, in various cuttings you can utilize that extra three inches. We do only a little processing in our plant. We have one straight line rip saw and a cutoff saw. Most of our lumber goes on the market in the rough form. I think that this concentration yard gives people a good kiln-dried product. People who are equipped to do that certainly perform a good business process themselves and at the same time contribute to the uplift of the small sawmill operator.

G. Skinner (Dimension Mill Equipment Co.): Do you think that manufacture of dimension stock ought to start with the woods operation?

Mr. Simmons: Yes, I definitely do. Second-growth hardwoods are of surprisingly good quality but are apt to be crooked, so it is an excellent idea to get the material pretty much to final length in the log form. You can get up to 20% increased recovery by sawing bolts from such trees, and a material increase in quality. I know one mill in Vermont where they buck their bolts down to two feet in length before they put them on the carriage because they need straight grained stock. Bolt lengths range from two to six feet. The operation is turning out a superior product. For economic reasons, however, this type of operation should be definitely confined to diameters under 14 inches and to lengths under 6 feet. It's another specialized operation.

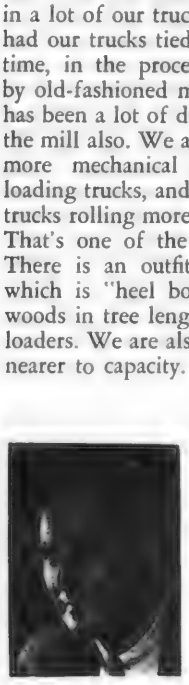
J. Stamps (Allen–Rodgers Corp.): If you're going to bring the logs to the sawmill rather than the other way around, you're going to have a trucking problem. I haven't seen too much

improvement in trucking methods. What do you have there?

Mr. Simmons: There have been great improvements in loading methods. That has been the sticking point in a lot of our trucking—that we have had our trucks tied up maybe half the time, in the process of being loaded by old-fashioned methods. Then there has been a lot of delay in unloading at the mill also. We are getting more and more mechanical loaders and self-loading trucks, and we are keeping our trucks rolling more of their work days. That's one of the big improvements. There is an outfit in West Virginia which is "heel boom" loading hardwoods in tree lengths with mechanical loaders. We are also loading the trucks nearer to capacity. Trucks in the Adirondacks are piled up to state highway load limit. So overall cost of trucking is at least holding its own on the better operations, despite the increased cost of equipment and labor to do the job. Another part of the solution is that we are making better use of more of the log volume. We know that small logs run a lot more tonnage per thousand board feet than big logs, but if we can turn more of that tonnage and cubage into useful and salable products, on a good permanently located mill, we're ahead of the game. I'm not discouraged about the trucking picture at all.

E. G. Locke (Forest Products Laboratory): I've been much impressed with what a slicer can do. You mentioned that maybe the sawmill of the far future might not be a sawmill at all. I wonder if maybe some such a combination as a slicer and sawmill might not be a piece of equipment which will be very useful in the future?

Mr. Simmons: It is entirely possible. I don't know too much about shears. There has been a lot of publicity about a German machine which looks like a big chipper with slicing knives. One difficulty, of course, that has to be overcome is knife checking in slicing. But there are opportunities there for certain classes of material. That probably is another specialized rig that we ought to be investigating very seriously.



The Future of Wood in Construction[1]

BERYL PRICE

Architect, Philadelphia, Pa.

A closer bond is urged between wood producers, architects, and the construction industry. The future of wood in building is dependent upon practical research into its uses. Means by which allied industries can cooperate are pointed out and several new uses listed that architects expect from wood in the years ahead.

ONE OF THE MOST VITAL means to communicate with those who use your product is to send direct mail on your subject and help prospects make up their minds as to where to best use the products you make and sell.

You might say that this has little or nothing to do with "The Future of Wood in Construction." However, future use of wood, and for that matter all materials in the construction industry, will ultimately be bound up ever more tightly with practical research into their uses. Today, in this research-conscious country of ours, architects and builders are spending millions of dollars of their time and clients' money in the most practical program (but also most wasteful) of building research ever carried on. As a result we are producing some of the most costly mistakes ever shouldered by the building dollar.

There are many instances where architects have used wood in close collaboration with the producers and artisans of the lumber and millwork fraternity with the most disastrous results. This is not to say that the same type of practice does not exist with the major parts of the construction industry. Only today, in a minute way, is the paint or hardware industry making even the faintest effort to study intelligent application of their product through the eyes of the architect and builder. And these two allied producers are bound to the wood producers of America just as closely as the glues and resins that bind the flitch and core of plywood together. Many of the failures and few of the successes of wood products can be closely allied to the failure of paint and hardware to perform its function.

It is respectfully suggested that some part of research efforts for the next five years be directed and channeled so that perhaps another architect or builder can stand before you and spread vistas so startling and unique as to demand that you come hear his astounding predictions. So wonderful will he describe the future uses of wood that a revolution of construction practice will take place each year at your annual meeting.

First, it is suggested that the Forest Products Research Society compile and issue a handbook, not only filled with the known computations of stress and strain, of mechanical and structural properties, but containing the known recommendations of wood and wood products which are now the limited practice of the manufacturer. Tell in easy-to-find form the million uses that plywood has taken. Where can a young architect or builder find the thickness of recommended doors and windows to be used for the many purposes now in existence?

We designed a hospital recently and were shocked to find that the architcet who previously worked for this client made the doors 6 inches too small when conditions actually demand that they be 6 inches larger than normal. Today doors twist, shrink, blister, and are never painted bottom and top. The famous prefabricated steel door frame, when used with plaster or concrete block, will almost always crack the plaster around the frame. Where are the words of wisdom, where are the years of long experience, that could guide the halt and the blind in architecture against these shortcomings? Such a document would be a wonderful gift to better architecture. Architects would then have more time with which to invent those wonderful things for which they have been trained and could come before you with more fertile thoughts of the future.

Secondly, mention should be made of "A Research Foundation for the

[1] Presented at meeting of FPRS Northeast Section Oct. 20–21, 1955, in New York City.

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Construction Industry" which made a feeble if hopeful start a few years ago in Philadelphia. It had the Franklin Institute's promise to undertake such a foundation in its laboratories and on its grounds with experimental buildings and materials exhibits. Such a foundation was a creature of the Philadelphia Chapter of the American Institute of Architects and had the support of the construction fraternity of the Philadelphia area. Some day it is hoped that, with the support of product manufacturers and all research groups, such an organization will actively thrive at the Franklin Institute and its famed monthly magazine will actually publish a paper on the development of a wood beam so light and so strong that steel and concrete will find real competition in low structural frames.

The Institute stands ready and willing to assign the scientific thinking and research brains to the beauty of wood and its more wonderful applications. The establishment of a research laboratory where the designer, architect, builder, and forest products manufacturer can come with an idea and actually see it built and tested for the good of mankind is a truly wonderful aim for men of the type and thinking represented in FPRS.

Architectural Trends

In recent years, after dependence for ages on stone for durability, the bright young men of architecture have turned to concrete and fine tensile materials like wire as the bright stars of building. They fight for ever-thinner curtain walls of paperlike quality. They produce geometrically perfect rectangles, ever seeking a simple solution, until this pattern has become so common as to be revolting, with every metal window manufacturer in the country in a fight to the finish for the face of every building to be built for the next five years.

The stark sterility of the concrete mass of Corbusier and the cold steel and glass of Miles Van Der Rhoe all seem to add to a soul-searching question, "Has the smile and soul been stolen from the Temple, has feeling and the rosy cheek left the fleeting glance and the face of a child?"

The answer as to what turn the future of building construction will take is not that wood will once more return as the Crown Prince of the designer's pencil. However, the native warmth of the material and the directed guidance of the wood industry can well make it the Dauphin of the next half century. It does not take much A million dollar advertising campaign for the multi-billion dollar construction industry seems like a small price to pay for telling the story of such a worthy material. Add to this the real story being carried out at Franklin Institute, the simple tale told by a handbook for the man who specifies, and the wonderful native beauty of the product, and wood's future is bright indeed.

What is the story with architects across the nation? As a biased user and lover of wood, I find that the men who design the smaller buildings are using wood products in ever-increasing quantity. And yet they are like a voice in the wilderness. What have you given them since plywood; perhaps striation and better glues but nothing of great import. The laminated structural members are a step in the right direction and the Timber Engineering Company should be given credit for the dynamic effort they put forth in clearly telling this story.

Beautiful redwood and wonderful cypress, delightful elm, deep tone ash, and wild gum—even raw these materials are truly God's gift to man. They do not have to be melted in a furnace, nor do they require that the water ratio be just right. They require a delicate sense of judgment in their use, a 24-hour search into their qualities and possessions so that even greater numbers may use them more wisely.

Prediction for Future

What would architects like to see of wood in the future and how would we use it if we could? I would venture into the unknown to say that architects expect of wood not less than the following in the next several years.

First, it is believed that reinforced wood will take its place with reinforced concrete and the steel beam. Men have laminated sheets of wood together, certainly they will refine the sandwich by inserting the steel sheet or bar in their laminated sections. Aluminum could well join forces with wood in this process to lighten the load. Each time my engineer and I pore over a new design and I show him some radical departures in span or use, he slide-rules me into oblivion with such a deep and massive section of timber that we quickly change to another material.

Second, the added strength of corrugation should open up thousands of uses for laminated shapes, particularly where they can be applied perpendicularly to a flat surface for strength. However, this application for wood merely apes the steel industry and has probably already been discarded as common.

Third, it is felt that wood will return to the floor which it has left for the vinyls and terrazzos. It will require little research to develop impregnated wood surfaces with fantastic qualities and designs to replace the floor tile industry. The ceramic industry has alienated itself from the building industry with its inability to deliver the requirements of mass production. The wood house has become the foreteller of the future. This is a trend that should be the apple of the industry's eye. Without reference to statistics, the requirements of the home building industry are on the increase in the use of wood and with research help will reach ever greater production heights.

It is amazing that the great strides made by wood in the war emergency were never fully capitalized on. Wood substitutes made the forest products industries the leaders of our war effort. What pinnacles should have been reached by reason of it! Little seems to have come from it but perhaps a mild effort at research.

Certainly the wood sandwich is a simple thing. Perhaps wood researchers have already produced the roof plank of the future. However, they have not yet produced it with the qualities of beautiful surface combined with strength and the added starter of acoustics and insulation in one 2- or 3-inch package with waterproof joints. I fully expect that within a short space of time wood joints will be welded and the beauty of the craftsman will disappear to be replaced with a stronger and better package. However, I hope that with added technology we will not see wood losing its smile and its heart to a world of science which could strip it of its one great quality that no other building material can surpass — its beauty.

Conclusions

A closer bond and tie is needed between architecture and the allied divisions of this industry. A joint program of practical research with an institution of national import should be encouraged not only for the producing of papers and conferences but for a more earthy solution where laboratory and test tube projects can be carried on with projects set up each year by a capable board to determine worth. Consistent with this, a series of regional meetings should be held with men who use wood products for the purpose of determining the lack of answers the product posesses.

Wood is a material quite glamorous in an industry not noted for its individual good looks. Its future is the brightest. It has always worn the most beautiful fur in the finished building. The building trades point them out as the craftsmen of the industry, but

they have also created a serpent in their company. Today quite often the design of a building will attempt to eliminate the hammer and saw from the finished product. Herein stands a semaphore with a bright red light and a note of caution. The research and technology of labor relations will have to be given a serious consideration if wood is to take its rightful place in the building of the future.

The challenge is not all the wood industry's. Architects too are thinking of all these things. We all need collective help and it is my firm conviction that the salvation of all of us lies in productive research and excellent public relations.

Discussion

W. B. Wilkins (Consultant): What do you think our position in the wood field today would be if we had been spending as comparable an amount of money for research as the aluminum people have been doing?

Mr. Price: I met with the chief engineer of the DuPont Corp. some years ago in an effort to get that firm to contribute $50,000 a year to run a research foundation for the construction industry at the Franklin Institute in Philadelphia. He smiled at this sum and advised that they spend something like $6 million a year on research for their home products alone. We don't have to look toward the aluminum industry, but merely glance at the chemical people. I think the wood industry is doing a job in research. However, both you and DuPont have skipped us. Perhaps the use of wood in other products is far more lucrative than its use in buildings. This is perhaps why research has not been directed to construction, or perhaps the competition is too keen. If we were to analyze the volume of capital in the wood industry, with everyone doing his part as he should, we would probably find a tremendous dollar contribution to wood construction research beneficial to the builder, the architect, the consumer and ultimately, the lumber industry itself.

J. R. Wilner (Wilner Wood Products Co.): If I came to you with a finished clapboard which you could put on a building without nails, any color you want, smooth, fire-proof, better than anything we now have, do you think your organization would actually go into it and start the building, try it out and make up the clapboard out of ground chips finished with plastics?

Mr. Price: There is a research foundation which has been started by the A.I.A. and ultimately such an organization will be in a position to accept materials, test them, and rate them for the profession and the industry. At the present time, no one is doing this job except private manufacturers for their own good with only the better factors given to the architect and the public. There are also isolated research efforts throughout the country, but most of them are in the talking and conference stage with few in the laboratory and testing stage. Architects cannot do this job unassisted. Comparing the contractor dollar with the industrial dollar is to compare a mountain to a molehill. This must be a combined effort of the entire construction industry with the architect, or whomever the industry might designate, as the examining and reporting agency. As to your product, which is in effect a copy of something now in existence, I would recommend that your efforts be dedicated to a use perfect for its consistency rather than to ape something for which it was never intended. If your aim is primarily to out-produce an existing product through a cheaper method, I suppose this is good. However, clapboard is not something that we push, it is part of a whole building and the value of your particular one is taken on its beauty, utility, and price. I believe that is self-evident. One of the big problems regarding wood is its ability to resist the elements. As to architectural association sponsorship of your product. I am certain this can never come to pass. It is my feeling that if a steel beam or wood beam could be made in exactly the same size and strength, architects would probably use wood because of its beauty. It is my belief that in heavy sections, wood would be more resistant to fire than steel.

Mr. Koch: (Western Electric Co.): The carpenter or builder himself comes in here. He has been doing more harm to wood. In other words, you can design a building good, we can supply good materials, but I think the average carpenter is doing more harm to wood in the building trade today.

Mr. Price: I believe the harm or good that carpenters might do to the use of wood depends on the skill of the mechanic. I feel that a more serious problem has arisen in that the building trades are more and more eliminating themselves from the construction picture. On each construction job that we do, a serious effort is made to substitute other materials for wood in order to eliminate the carpenter. He appears at this time to be the highest cost in the building industry. To me the carpenter and the millworker are the finest mechanics and craftsmen. The carpenters are vitally needed; their job is one of great importance and it is a sad commentary that mechanics and materials of such beauty and utility can be forced out of the construction picture through a complete misunderstanding of both the labor union and the employer. Here is a real job for research. A good research foundation working for the industry would have recognized this problem and helped to solve it before it grew too serious.

Furniture of the Future[1]

RUDOLPH WILLARD

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A projection is made into the future on the probabilities and possibilities of new techniques, research, and development in household furniture. The author suggests standardization of component parts, simpler and cheaper frame construction, and development of cores from other materials. Recent developments are reviewed and prediction made of wood's place in furniture of the future.

FURNITURE IS A CONSUMER PRODUCT which is purchased by the housewives of the country for use in their homes. In this respect it differs from lumber which is bought for use as a material from which something else is made. Over the long pull, furniture is going to be what the women want it to be. If you can forecast what the women will want 50 years from now, you can make a good start on predicting what the furniture will be at that time. So one of the big advances of the future will be more accurate methods by which furniture manufacturers can determine what Mrs. America wants.

Improved techniques of market surveys and market analysis will be developed and will be much more widely used. There will be closer correlation and closer working together in the chain of distribution from designer and manufacturer through transportation, storage, jobber, retailer right through to the woman in her home.

Harmony Throughout Home

In addition to giving Mrs. America what she wants, we will also see an intensification of the educational campaign to upgrade her tastes and her ability as a decorator to make the furniture tie in with house, rugs, drapes, and other household furnishings to the end that everything in and about her home harmonizes and furthers the expression of the kind of life she wants to live in her home. The women's magazines have done a lot of effective work along these lines and we will see it improved and intensified. Advertising, television, home shows, dealers' displays, and other media of education will be working toward the same end.

In recent years a great deal of stress has been put on "functional" design and construction of furniture. But in many cases "function" has been interpreted in a narrow sense. The primary outstanding function of furniture is to dress up a home according to the ideas of the woman who lives in it. Her home is second only to her personal appearance. The function of a woman's hat is to express her individuality and to attract favorable attention. Furniture is much the same. It needs reasonable utility values such as comfort, convenience, durability, freedom from trouble, but it is bought primarily for aesthetic and decorative values many of which are pretty intangible and subjective.

Due to the tremendous number of differences in personality and taste among women there will always be a tremendous number of different looking furniture items made. Standardization of appearance will not go far. This diversity of product has always influenced furniture manufacture and will continue to do so. There are many mass production techniques used in other industries which are not used in furniture. The basic problem is not related to mass production as much as to mass sales. It does not seem likely we shall ever achieve mass sales in furniture.

The furniture industry of the future must retain its production of many different items and also its flexibility to drop items and bring out new ones. It cannot hope to go as far in automation as many other industries.

Standard Sub-Assemblies

In spite of this, we shall see great strides in standardizing component parts or sub-assemblies so that they can be produced in bigger lots at lower costs. As an industry, we have paid too little attention to possibilities along these lines. This is particularly true of parts which do not show in the finished piece of furniture and consequently do not affect the appearance.

For example, most beds have side rails. They are purely structural members and do not show when the bed is made up in the home. A typical wood side rail involves: 2 or 3 strips of edge-glued wood, 1 slat bearer, 6 screws to attach slat bearer, 2 bed hooks, 4 pins in the bed hooks, and 4 pins in the posts for hooks, or a total of 19 parts.

Each of these parts requires several operations to make. They must then be assembled and finished. For a subassembly like a side rail which can be completely standardized, this seems far from ideal. There must be cheaper ways. Somebody will come up with a moulded or formed rail all in one piece that is prefinished in moulding.

As far as that is concerned, why have side rails? Bed springs must have a bottom frame. Why not make it a little stiffer, arrange for attachment direct to headboard and footboard and do away with side rails entirely?

A typical drawer consists of: 1 drawer front, 1 drawer back, 2 drawer sides, 1 drawer bottom, 1 center guide, and 8 or 10 glue blocks, or a total of 14 parts, each with several operations as well as assembly, fitting, and finishing.

The drawer front is all that shows. Somebody will come up with a one-piece, moulded, prefinished drawer to which a front can be easily attached. As a matter of fact, there are on the market today case pieces in which each drawer is moulded in one piece. There is no particular advantage costwise at present, but that can and probably will change.

Simpler and Cheaper

The structural frame and dust proofing of a case such as a chest of drawers does not need to show. This would not be as easy to work out in one piece as a drawer or a side rail but there will probably be developed a new type of construction simpler and cheaper than present methods.

The three examples above are all alike in the respect that they are purely structural and do not show on the outside of the finished piece of furniture. In this sort of a situation, the furniture industry needs to get away from thinking purely in terms of making parts out of lumber and their assem-

[1] Presented at meeting of FPRS Northeast Section, Oct. 20–21, 1955, in New York City.

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bling. We need to keep up with advanced techniques in working metals and plastics.

For cores on which veneers are applied, we might well consider what gypsum board has done as a sheet wall material. It is pretty cheap. Maybe it could have a veneer face instead of paper. Maybe it could be made in shapes other than a flat sheet. And for cores we should not overlook the cheapest of all materials, air. Present honeycomb paper core may not be the best answer, but it is worth thinking about. The flush door people are doing a lot of work using air for cores. It will pay to watch their development work. Chipcore is one of the newer basic furniture materials which holds promise. The main thought here is that furniture manufacturers should watch developments in materials other than lumber.

Outlook for Wood

What is the future of wood in furniture? For exposed surfaces, the attractive grain of woods such as mahogany, walnut, maple, and cherry has wide appeal. It also has a long tradition back of it and will probably be widely used for a long time. As a purely structural material, wood has some advantages. One of the big ones is that of low tooling cost to produce an item of a new size or shape. This is not true of materials which are moulded, cast, extruded, or rolled. For small lots and frequent changes, wood might easily beat the cost of other materials on account of low tooling cost.

Fine attractive grained woods are becoming scarcer. The trend will be toward more veneered construction using the fine woods only as thin faces. At the same time, the newer glues permit use of plywood which is more durable than solid wood, and at reasonable cost.

As time goes on, many other materials may become accepted and desired for their appearance. Fabrics, of course, are now desirable as covers for upholstery. Many developments in new fabrics can and will be applied to upholstery covers. Recent examples are metallic threads woven into fabrics, fabrics made from synthetic fiber yarns, and sheet plastics. Many synthetic, resin-bonded laminates now have excellent reproductions of wood grain, but there was also a day when marble tops were in great demand. It is probable that some of the newer materials will have desired appearance by themselves without trying to imitate wood or imitate anything else. Wrought iron has had a recent vogue. My guess is that it will not last, but who can tell. In short, wood grain has attractive appearance, but other materials may also. Do not concentrate on wood to the exclusion of other possibilities.

Finish is one of the most important processes in furniture. It has a great deal to do with attractive appearance. Ordinary wear and tear in a home is more apt to show up in harm to the finish than to strength, comfort, or other characteristics of the furniture. New finishing materials are being developed so fast that it is safe to say that the finishes of the future will completely outclass what is now known in beauty, durability, and low cost. Research probably plays a bigger part in new finishing materials and techniques than in any other furniture material or process, with the possible exception of adhesives. Fortunately, this research is closely akin to chemical research. The chemical industry has gone farther in research than most industries and research snowballs; the more you have done, the easier it is to go further.

Research in Comfort Factor

While appearance is of first importance and utility is secondary, there is one category of furniture where a utility factor is of prime importance. In chairs, davenports or other pieces to sit on, comfort is as important as appearance. Little basic information is available on comfort. In a general way we know that posture is involved; we know that hardness or softness is involved; we know that people have different sizes and shapes of bodies. But talk to any chair manufacturer and he will admit that when a new chair is designed nobody knows whether it will be comfortable or not until after one is built, tried out, and generally changed several times. In the years to come we will learn more about what it takes to make a chair comfortable. Often a comfortable chair costs no more than an uncomfortable one. Chairs of the future will be comfortable because we will find out what factors are involved in comfort.

The bedding industry is ahead of the furniture industry with respect to comfort. One large operator offers one mattress-box spring set for folks under 110 pounds, another for folks from 110 to 150 pounds, another 150 to 190 pounds, etc. But even the bedding industry is a long way from the ultimate. People still buy an expensive spring and mattress for comfort and then largely nullify the spring by buying a bed board to put over it to cure backache.

The whole field of spring and upholstery construction is badly in need of research. Why do many upholstered pieces which are comfortable at first degenerate over the years into the bumpy, shaky, saggy, uncomfortable pieces you find in many older homes? Can they be tied or otherwise stabilized so that 10 or 15 years' service will not impair stability? Can steel springs be designed and processed so that in service they do not exceed the elastic limit and become deformed? Can they be mounted on bottoms which will stand up? Can filling materials be found which do not mat or become bumpy? Is foam rubber the answer? In upholstered furniture of the future, research will have provided satisfactory answers and at reasonable cost.

Automation Ahead

Furniture is much higher than most industries in the percentage of total price which is expended on labor. This means extra pressures and also extra opportunities to replace men with machines. There are some hurdles to be jumped. First is the necessary diversity of product and relatively small manufacturing lots. Standardization of parts and sub-assemblies which will not hurt final appearance can help on this. Second is the fact that machinery manufacturers have much broader markets in metalworking machinery than woodworking. Many have changed their major emphasis away from woodworking machines.

Mechanization is desirable, possible and necessary in furniture production. But the furniture manufacturer of the future will be forced to build a lot of his own special machinery, or to modify, combine, and rebuild standard machinery to suit his own plant and problems. This may sound as though the big furniture factory will have an extra advantage over the little factory, but that is not necessarily so. In the novelty turning industry, many small plants have built much of their special machinery and compete all right with the larger ones. The same is true in some parts of the wood chair industry. One plant built its own electronic assembly jigs and reported that they paid off handsomely. It's not a question of size; it's a question of ingenuity and the will to do. In the furniture factory of the future, much hand labor will be mechanized.

Transportation cost and the cost of packing for transportation is taking an ever-increasing percentage of total delivered cost. The furniture of the future will go more and more towards knock-down and semi-knock-down construction to reduce transportation cost. There may also be an increase in chain operations where parts are made in a central plant but final assembly is in regional plants near concentrated market areas. If you think I'm crazy, consider the automobile industry.

We are on the threshhold of the greatest era of dynamic change the world has ever known. Just because something has been done one way, don't hesitate to dream about other ways. And don't overlook what other industries are doing. Maybe it could be modified and adapted to yours, or at least it might give you a new viewpoint to start thinking from.

Discussion

C. L. Babcock (Babcock Machinery Co.): My idea of ideal future timber conversion is to put the logs in one end of a machine and take the product out of the other.

Mr. Willard: There is one drawback to that. If you don't have an interlock on the reversing switch and some fellow throws it the wrong way, you would convert a warehouse full of furniture back into lumber.

Mr. Babcock: I almost saw this done. They were putting logs through a sawmill and everything was being assembled on a conveyor. The only reason everything wasn't automatic was because the boards had to hesitate a little in the dry kiln to be dried.

E. R. Stivers (Package Research Laboratory): If the manufacturer wants to assure himself of the acceptability of his product, what test procedures can he go through now instead of having to wait several years for customer reaction?

Mr. Willard: At the moment, practically none. It's a big gamble. That's one of the reasons why I believe that one of the real research developments of the future is going to be along the line of market research and market analysis. In many other industries, they have made tremendous headway in this field. It's fantastic how sucessful the cosmetic people have been, for instance, in finding out what women want before they get it on the market. We haven't done much of that in furniture. That, in my opinion, is one of the big developments of the future in furniture.

J. A. Hauter (Allan Wood Products): I'd like to comment on this business of extruding parts. Just two weeks ago I witnessed the extrusion of parts of a very intricate shape. It wasn't with the furniture industry but it could well have been. We might be much closer to that than we may expect right now. What we need is wider appreciation and wider application of the process, even though there will be technical questions.

Mr. Skinner: What will the importance of color styling be in furniture of the future?

Mr. Willard: I believe that in furniture of the future, more emphasis will be put on color than we've ever had. We've always put a lot on it, but if you think of furniture as a decorative feature of the home and you go and look at some of these new home developments, you will be impressed with the use of color. They're going off the deep end on coloring and you're going to find, in my opinion, that this will be an extremely important effect on future development in furniture. I'm reminded of an old timer, a furniture designer, who said that in his next incarnation he was going to write the ten commandments of furniture design and he hadn't got any further than the first commandment, that was: "Thou shalt give them warm colors." I think people like warm colors.

R. I. Solow (Keller Products, Inc.): How about this functional trend in furniture that we have today as opposed to strictly a decorative product? It seems now that they're using furniture for its functional rather than its decorative value.

Mr. Willard: There is an awful lot of talk about that. My own feeling is that it is a flash in the pan because of the fact that for so many years we've disregarded function. Let's take a table. Functionally, what's it for? It's to put pork chops on when you sit down to dinner. Pork chops would taste exactly the same if you ate them off a barrel; but you don't. Your wife shakes you loose from $700 for a beautiful dining room suite.

J. Batson (Kittinger Co.): As far as functional furniture is concerned, back in the last century they had more trick gadgets of furniture of the time than we ever think of putting on now. If you go to the museums, you'll find that they did more things with furniture than nowadays. I don't think the wood industry has to worry much about the furniture industry going to some other type of material. We've found that people start out and buy modern furniture and functional stuff; then when they're able to get a little money together, they come back and want to have the traditional wood furniture.

Mr. Willard: I would like to make just one more remark on functional. I've been talking down practical things here. That does not apply to the type of furniture that you sit on, such as chairs, davenports, and sofas. There, I fully believe, that comfort is a legitimate top function and it seems to me a tremendous amount of work should be done on it.

Newell Norton (Penn State University: In the future, what sort of macine cutters and saws will we have and what will they do in comparison to the present operation?

Mr. Willard: This whole question of cutters and saws is very much up in the air at the moment. Of course no machine is any better than the cutting tool. As a matter of fact, the American Society of Tool Engineers has quite a fund of money available for any people in a position to do some research. They're very unhappy about tools and cutters that are being used for wood. My own thinking is that we're taking too much for granted. Let's glance at the future a little bit. I'm not at all sure that the round cylinder with knives is the right answer. In the first place the thing doesn't cut a flat surface, it cuts a washboard. In the cutting of metal, the speed of the removal of the metal is limited by heating of the tool. In extremely few woodworking cutters is that the limiting factor. The limiting factor is usually torn grain in the surface. What we know about that is pitiful. We don't know. I look for a tremendous amount of research on cutting action. We don't even know the fundamentals of cutting action and cutters. Then there is also the whole field of the material of which the cutting edge is made. Old timers have seen it go from cahbon steel to high speed steel to carbide. Even the best of them wear more than we like to have them. The tungsten carbide stands wear pretty well but we can't get a really keen edge on it. It's brittle. I think there will be a basic revaluation of the cutting action and metallurgical development on the knife itself.

Mr. Babcock: One point that hasn't been covered is the question of the production of furniture. We now have the rough cut lines that go from the rough cut lumber to the glued-up panels in about fifteen minutes, and from then on it's just a matter of hand-juggling it around—pulling the lumber around to a lot of machines until you come to the built-up cabinet in the white. From there on it goes through automatic finishing line-up. What's going to happen in the future between the glued-up panel and the finished cabinet in the white? How is that going to be automatically arranged? It seems to me as though it's a matter of design. It's certainly a matter of conveyorizing. It's a matter of not having small quantities.

Mr. Willard: I agree with you. It's largely a matter of the science of following along with standardization wherever you can. I think you will see the day when the furniture factory finishing machine room doesn't look anything like it now looks. It will have a little integrated line for producing drawer interiors or some other series of parts which can be standardized. At the side we will have the old custom shop which is all we've got right now to take care of the cats and dogs and the odds and ends.

H. Bennett (Behr–Manning): There has been a lot of development in the lamination of top panels and doors as well as molded plywood chairs. Do you think that perhaps a more expensive suite of furniture in time will be made of wood laminations?

Mr. Willard: Yes, I do. I think manufacturers are almost forced to go to these materials because fine woods with their beautiful appearance are getting scarce. But you can cut them thin into veneers and get the appearance that you want. Also, in the last few years we have learned an awful lot due primarily to synthetic resin glues. It is entirely feasible now to make laminates that are more durable than solid wood. In that field I look for some violent changes in respect as to what is under the veneer. Take the matter of sheet rock, about the cheapest thing you can put up on a building. I dont know why that has to have a paper face. Maybe it can have a veneer face. The gypsum is apparently cheap. Maybe we will wind up with gypsum cores. Maybe it doesn't have to be flat sheets. Maybe it can be molded to form. While we're thinking of structural material, don't forget air. That's the cheapest structural material we've got. As you go into the mechanics of it you find that if you take two flat surfaces you have a terrific strength, provided you can keep them at the same distance apart. Those paper honeycomb doors are pretty close to 100% air. I'm not sure that's the right answer but if we work along that interesting line, I think we're going to see the day when there is going to be a good deal more air used as structural material in furniture.

Handbook for Small Sawmill Operators

How to Attain and Maintain Accuracy of Cutting

Glossary and Appendix

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and

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Defines terms used throughout "Handbook for Small Sawmill Operators". Appendix contains reference tables which will assist in efficient operation of small sawmills.

GLOSSARY

Air dried—Lumber which has been stacked after sawing in the open air, in open piles (stickers inserted between each layer) and which has come to approximate equilibrium with the moisture content of the air.

Arbor—The shaft and bearings on which a circular saw is mounted. (Syn. — Mandrel, or main drive shaft.)

Band saw—An endless beltlike blade of steel, toothed on one or both edges, which is used to saw lumber.

Bearings—A support or guide in which the journal, shaft, pin, or the like, turns or revolves.

Boards—Lumber less than 2 inches in thickness.

Board foot—A unit of measure in the lumber trade. A board foot is a section 12 by 12 inches in size and 1 inch thick, or its equivalent volume.

Board mill—A sawmill that makes a specialty of manufacturing 1/4-inch or 8/4-inch lumber, as compared to a mill that makes a specialty of material of greater thickness.

Bolster—A horizontal structural part intended to afford support for logs on a sawmill carriage. (Syn. (in West) — headblock base.)

Boss dog—A dogging device on the knees of a sawmill carriage consisting of opposed lever-controlled talons which can be brought to grip with the outer surface of a log, cant, or timber.

Boxed heart—The term used when the pith falls entirely within the four faces anywhere in the sides of the length of a piece.

Cant—A part of a log that has been slabbed on one or more sides.

Carriage—A frame on which are mounted the headblocks, setworks,

PREFACE

The Handbook for Small Sawmill Operators was prepared by the Logging and Milling Committee of FPRS at the request of Sectional Committee B–66 of the American Society of Mechanical Engineers.

The material has been divided into six parts being published serially in the Forest Products Journal. It will be available later as a separate bulletin from the Standards Department of ASME, 29 West 39th St., New York 18, N. Y.

Publication of this Handbook by FPRS and ASME is not to be construed as establishing any new dimensional standards for lumber. Such standards are promulgated by the American Lumber Standards Committee for softwoods and by the National Hardwood Lumber Association for hardwoods. It is designed specifically to show the small sawmill operator how he can produce lumber to those standards more economically and most efficiently.

Acknowledgment is due many people, representing the several groups interested in the small sawmill business in various ways, for the constructive help and advice given in this handbook compilation. The Committee is very grateful to all those who helped so generously.

FRED C. SIMMONS, *Chairman*
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and other mechanisms for holding a log while it is being sawed, and also for advancing the log toward the saw line after a cut has been made. The carriage frame is mounted on trucks which travel on tracks.

Centrifugal force—The force which impels a thing or its parts outward from a center of rotation.

Check—A lengthwise separation of the wood, the greater part of which occurs across the rings of annual growth.

Chip—A shaving or segment taken by a single sawtooth. Also wood fragments made by hogs or chippers.

Circular headsaw—A circular plate having cutting teeth on the circumference and used to ripsaw logs.

Clearance angle—The angle between a tangent to the cutting circle of a saw tooth and a line along the top of the tooth intersecting the tangent.

Collar—A metal ring or round flange upon, surrounding, or against an object and used chiefly to restrain motion within given limits, to hold something in place.

Conical roller bearings—Roller bearings with tapered rollers.

Custom sawing—Lumber sawed under contract for someone else. Generally sawed to owner's specifications.

Cutting face—That part of a saw tooth which extends from the point or edge down toward the gullet, a distance equal to that where cutting or shearing of fibers is done.

Dimension (softwood)—All yard lumber except boards, strips, and timbers; that is, yard lumber 2 inches and over in thickness, but less than 5 inches thick, and of any width.

Dimension stock (hardwood)—Small selected cuttings of hardwood, accurately sized and sometimes semi-finished for use as furniture parts and for other purposes.

Dog—A steel, toothlike projection that is attached to a carriage knee and usually operated by a lever. Carriage dogs are used to hold the log firmly on the carriage.

Dog board—In sawing lumber on a headsaw, the last board in the log to which the carriage dogs are attached. (Syn.—backing board.)

Dogging—Process of fixing the dogs into the wood and releasing them from it.

Dressed lumber—Lumber that has been dressed or surfaced on one or more sides.

Edge—To make square edged.

Edger—A machine used in sawmills to square-edge any lumber parallel to its long axis and also to rip lumber. It consists of a frame supporting an arbor on which are mounted one to several circular saws.

Edgings—Strips that are cut from the edges of boards.

Eye (saw)—The hole through the center of the saw which receives the shaft.

Face (log)—Generally, a quadrant of the surface of the log which is parallel or at right angles with the saw when placed on the carriage. Also, the flat surface resulting when a slab has been removed.

Feed—In sawing lumber, the linear length of log, expressed in inches, which is cut at each revolution of the saw.

Feed works—The mechanism which moves the carriage past the saw.

Filer—The man who sharpens, fits, or maintains saws in a sawmill or other woodworking plant.

Fixed collar—A collar firmly attached to the saw arbor, as distinguished from a loose collar, which is held to the arbor with a nut.

Flitch—A section cut from a log which has wane on one or both edges. Usually destined for resawing.

Footage—Quantity of lumber expressed in board feet.

Gage—A standard series of sizes indicating by numbers the thickness to which saws are made.

Gig—The act of running the sawmill carriage back after a board is cut from the log.

Green—Unseasoned, wet.

Ground floor mill—Any mill not using a floor raised off the ground.

Guide (saw)—A device for steadying the saw.

Guide blocks—The arms of the saw-guide mechanism which hold the guide pins.

Guide pins—The parts of the saw guide which actually contact the saw. Usually end-grain hardwood blocks.

Guide rail—The rail that guides the movement of the sawmill carriage.

Gullet—On a saw, the rounded cavity between the teeth in which the sawdust accumulates and is carried from the cut. (Syn.—throat.)

Hammering—The art of pounding a sawplate on an anvil with a hammer in order to stretch the steel to the desired degree to overcome tensions produced in sawing. Also includes leveling. (Syn.—tensioning.)

Headblock—That portion of a sawmill carriage on which the log rests. Each headblock consists of a base, a knee, dogs, and a rack and pinion gear or some other device for advancing the knees toward or withdrawing them from the sawline.

Headrig—This is a term used by sawmill men in the field to describe parts of the sawmill equipment used for breaking down the log itself; that is, for sawing slabs and boards off the round log. In some sections of the country the term is confined to the sawing equipment itself, being descriptive only of the type of saw and the drive; "circular headrig with 48-inch bottom saw and 36-inch top saw, direct connected to a 100 hp electric motor"; "one 6-foot band headrig, belt driven from a 100 hp Diesel engine", etc. Other sections of the country use it to describe the breakdown machinery to include the carriage and sometimes the carriage feed.

Heartwood—The inner layer of wood which in the growing tree has ceased to contain living cells and in which the reserve materials have been removed or converted into heartwood substances. It is generally darker in color than sapwood though not always clearly differentiated from it.

High speed steel—Alloy steel which is heat treated and retains much of its hardness and toughness at high temperatures. Used for some saw teeth.

Holder (sawtooth)—A device for locking inserted saw teeth in a circular saw. (Syn.—shank, half-moon, circle, etc.)

Hook—Angle between the face of a sawtooth and a line drawn from the extreme point of the tooth to the center of a circular saw.

Husk—The frame supporting the arbor and other working parts of a circular headsaw.

Inserted point tooth—The tooth that can be removed and replaced in an insert point saw plate.

Jointing—The act of reducing points of all teeth in a circular saw to the circumference of a true circle when the saw is rotated; it is accomplished by abrasion.

Kerf—The width of the cut made by a saw.

Kickback—A sharp reversal of motion of the log or board during sawing, caused by a binding of the kerf slot on the saw. This may be caused by timber bind, where the sawn piece twists back toward the main part of the log or cant, or by a wedging action of a sliver

getting between the saw and the wood. Kickback occurs on edgers, mainly, and occasionally on headsaws.

Kiln dried—Lumber dried in a compartment (kiln) under controlled conditions of heat and humidity.

Knee—The part of a sawmill carriage headblock that bears the carriage dogs and supports the rear of the log away from the saw. It also supports the levers used to operate both the carriage dogs and the taper set.

Lead—Adjustment of the saw so that the distance to the track rail is slightly less at the front than at the back edge in order to hold the saw in the cut and give clearance to the back of the saw.

Left hand sawmill—A sawmill in which the carriage is on the left hand side of a person standing on the log deck and facing the saw.

Lift truck — A conveying device mounted on pneumatic tires or crawler tracks with arms used to lift, transport, and deposit loads of lumber, logs, or other materials. Lift trucks are of two types: fork and straddle.

Log-beam mill—The type of mill employing a carriage on which the knees, dogs, and sometimes the setworks are fixed to a movable beam extending lengthwise of the carriage frame.

Log rule—A table showing the estimated number of board feet of lumber that can be sawed from logs of various lengths and diameters.

Log turner—A device used to turn the logs on the carriage.

Loose collar—The collar that is held against the circular saw by a nut on the end of the mandrel.

Lug pin—A metal pin chambered in the fixed and loose collars on the mandrel and passing through a pin hole in the saw plate to prevent the saw from slipping on the shaft.

Main shaft — (Syn. — mandrel, arbor.)

Mandrel—(Syn.—arbor.)

Moisture content—The weight of water in a piece of lumber. Generally expressed as a percentage of the oven-dry weight of the wood.

Pawl—A pivoted tongue or sliding bolt on one part of a machine, adapted to fall into notches or indental spaces on another part. Used in set works on a sawmill carriage.

Pinion—A small gear with teeth designed to mesh with those of a larger gear or with a rack.

Plain sawed—Lumber sawed parallel to the pith of the log and approximately tangent to the growth rings.

Quarter sawed—Lumber cut parallel to the radius of the log rather than tangential to it. Practically applied—lumber in which the annual rings are at an angle greater than 45° with the face of the board. (Syn.—vertical grain, edge grain.)

Rack—A bar with teeth in one face for gearing with those of a pinion.

Resaw—A machine to cut boards, cants, slabs, or other material lengthwise into two or more pieces.

Right-hand mill — A sawmill in which the carriage is on the right hand side of a person standing on the log deck and facing the saw.

Rip—To cut a piece of wood lengthwise in the fiber direction.

Rip tooth—The kind of a sawtooth adapted for cutting parallel to the fibers and main axis of wood.

Roller bearings — An anti-friction device made up of a series of rollers rotating between an inner and outer metal race. The races can be tapered so that the bearing can carry a thrust load as well as radial load (See "conical roller bearings").

Sapwood—The living portion of the wood in the tree located in a zone of varying thickness just under the bark. Generally lighter in color than the heartwood.

Setout—A lever attached to the knee of a sawmill carriage headblock which can be used to place the knee out of alignment. It is of service in supporting crooked logs and in sawing tapered logs parallel to the bark. (Syn.—taper bar or taper knee.)

Setshaft—The shaft on a sawmill carriage to which the pinions are fastened and which causes the knees to advance or recede as it is turned.

Setting—The process of advancing the log on the carriage the distance required to get the sawed thickness desired.

Set wheel—The wheel on the setworks attached to the setshaft which, when turned with a lever, causes the knees to advance.

Shank—(Syn.—holder.)

Shim—A thin piece of metal, wood, or other material used to fill in, as in leveling.

Shipping dry lumber—Lumber that has been partially dried to reduce weight and freight costs, but may still have a moisture content of 30 per cent or more.

Shoulder—An abrupt projection that forms an abutment on an object.

Sills—The horizontal timbers supporting the husk of a sawmill.

Side dressing—The act of adjusting all sawteeth on a saw to project laterally the same distance from the plate.

Side gage—A measuring device to indicate the amount of lateral projection of sawteeth beyond the surface of the saw plate.

Slab—The curved exterior portion of a log that is removed to give the log a flat face.

Solid tooth saw—A saw having the teeth cut into its edge.

Spreader—A thin disk or scythe-like blade fixed behind a circular headsaw to guard against the boards and pieces contacting the rear edge of the saw and kicking back toward the sawyer.

Spring set—A method of setting saws whereby one tooth is sprung to the right and the next to the left. Most commonly used on crosscut saws.

Stickers—Strips of wood used to separate layers of lumber in air- and kiln-drying.

Stop shoe—The part of the setting mechanism on a sawmill carriage which contacts the peg or backstop and shuts off further advance of the knees.

Swage set—To spread the ends of the teeth in a saw to a width greater than the thickness of the saw plate.

Taper bar—See "setout".

Tension—To make a circular saw looser in the mid-radial zone than on the cutting edge (see "hammering"), so that when revolving at high speed it cuts straight and true.

Throat—See "gullet".

Tie or timber mill—A sawmill that specializes in the production of ties or heavy timbers.

Tram—A wagon, cart, or other conveyance running on rails. Used to transport lumber around a yard or mill.

Turning—Rotating the log on its longitudinal axis.

Upset swage—A tool used to spread the points of the teeth of a band or circular saw.

Wane—Bark or absence of bark on the edges or corners of a piece of lumber, dimension, or timber

APPENDIX

Table 2.—COMPARISON OF LOG RULES
(Values given are for 16-foot logs only)

Contents of log in board feet by rule stated—	Top diameter of log inside bark (inches) 6	10	14	18	22	26	30	34	38	40
International (¼" kerf)	20	65	135	230	355	500	675	870	1,095	1,220
Scribner										
Scribner	(18)*	54	114	213	334	500	657	800	1,068	1,204
Decimal C	(20)*	60	110	210	330	500	660	800	1,070	1,200
Doyle	4	36	100	196	324	484	676	900	1,156	1,296
Doyle and Scribner	4	36	100	196	324	484	657	800	1,068	1,204
Holland or Maine	(20)*	68	142	232	363	507	706	900	1,135	1,261
Blodgett or New Hampshire	26	66	123	197	287	397	514	666	827	914
Humphrey or Vermont	24	67	131	216	323	451	600	771	963	1,067
Bangor	(23)*	69	137	238	369	526	697	892	(1,110)*	(1,220)*
Square of three-fourths	(27)*	75	147	243	365	507	675	867	1,083	1,200
Herring	19	53	107	183	284	411	567	752	(960)*	(1,080)*
Ontario	17	57	121	209	320	454	612	793	998	1,109
Quebec or Roy	20	65	135	231	353	500	673	871	1,095	1,217
New Brunswick	20	64	130	229	362	507	706	....	....	...
Spaulding	..	50	114	216	341	488	656	832	1,066	1,200

*Figures in parentheses are extensions of original rule for diameters not included by author.

Table 3.—LUMBER SCALE

Size in Inches	Lengths in Feet 10	12	14	16	18	20	22	24
1x2	1⅔	2	2⅓	2⅔	3	3⅓	3⅔	4
1x3	2½	3	3½	4	4½	5	5½	6
1x4	3⅓	4	4⅔	5⅓	6	6⅔	7⅓	8
1x5	4⅙	5	5–5/6	6⅔	7½	8⅓	9⅙	10
1x6	5	6	7	8	9	10	11	12
1x7	5–5/6	7	8⅙	9⅓	10½	11⅔	12–5/6	14
1x8	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
1x10	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20
1x12	10	12	14	16	18	20	22	24
1x14	11⅔	14	16⅓	18⅔	21	23⅓	25⅔	28
1x16	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
1x18	15	18	21	24	27	30	33	36
1x20	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
1¼x4	4⅙	5	5–5/6	6⅔	7½	8⅓	9⅙	10
1¼x6	6¼	7½	8¾	10	11¼	12½	13¾	15
1¼x8	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20
1¼x10	10–5/12	12½	14–7/12	16⅔	18¾	20–5/6	22–11/12	25
1¼x12	12½	15	17½	20	22½	25	27½	30
1½x4	5	6	7	8	9	10	11	12
1½x6	7½	9	10½	12	13½	15	16½	18
1½x8	10	12	14	16	18	20	22	24
1½x10	12½	15	17½	20	22½	25	27½	30
1½x12	15	18	21	24	27	30	33	36
2x4	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
2x6	10	12	14	16	18	20	22	24
2x8	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
2x10	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
2x12	20	24	28	32	36	40	44	48
2x14	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56
2x16	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
2½x12	25	30	35	40	45	50	55	60
2½x14	29⅙	35	40–5/6	46⅔	52½	58⅓	64⅙	70
2½x16	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
3x6	15	18	21	24	27	30	33	36
3x8	20	24	28	32	36	40	44	48
3x10	25	30	35	40	45	50	55	60
3x12	30	36	42	48	54	60	66	72
3x14	35	42	49	56	63	70	77	84
3x16	40	48	56	64	72	80	88	96
4x4	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
4x6	20	24	28	32	36	40	44	48
4x8	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
4x10	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
4x12	40	48	56	64	72	80	88	96
4x14	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112
6x6	30	36	42	48	54	60	66	72
6x8	40	48	56	64	72	80	88	96
6x10	50	60	70	80	90	100	110	120
6x12	60	72	84	96	108	120	132	144
6x14	70	84	98	112	126	140	154	168
6x16	80	96	112	128	144	160	176	192
8x8	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
8x10	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160
8x12	80	96	112	128	144	160	176	192
8x14	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224
10x10	83⅓	100	116⅔	133⅓	150	166⅔	183⅓	200
10x12	100	120	140	160	180	200	220	240
10x14	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280
10x16	133⅓	160	186⅔	213⅓	240	266⅔	293⅓	320
12x12	120	144	168	192	216	240	264	288
12x14	140	188	196	224	252	280	308	336
12x16	160	192	224	256	288	320	352	384
14x14	163⅓	196	228⅔	261⅓	294	326⅔	359⅓	392
14x16	186⅔	224	261⅓	298⅔	336	373⅓	410⅔	448

Table 4.—STANDARD SAW GAUGES

Gauge (Birmingham)	Fraction Inch		Thousandths Inch	Millimeters
	1		1.000	25.40
	7/8		.875	22.225
	3/4		.750	19.05
	5/8		.625	15.875
	1/2		.500	12.70
	15/32		.4688	11.905
0000	29/64		.454	11.53
000	27/64	Full	.425	10.79
00	3/8	Full	.380	9.65
0	11/32	Scant	.340	8.64
1	5/16	Scant	.300	7.62
2	9/32		.284	7.21
3	1/4	Full	.259	6.57
4	15/64		.238	6.04
5	7/32		.220	5.59
6	13/64		.203	5.18
7	3/16	Scant	.180	4.57
8	5/32	Full	.165	4.19
9	5/32	Scant	.148	3.76
10	1/8	Full	.134	3.40
11	1/8	Scant	.120	3.05
12	7/64		.109	2.77
13	3/32		.095	2.41
14	5/64	Full	.083	2.10
15	5/64	Scant	.072	1.82
16	1/16	Full	.065	1.65
17	1/16	Scant	.058	1.47
18	3/64		.049	1.24
19	..		.042	1.06
20	....		.035	.89
21	1/32		.032	.81
22	..		.028	.71
23	....		.025	.64
24	....		.022	.56
25	.....		.020	.51
26	.....		.018	.46
27	1/64		.016	.41
28	.....		.014	.36
29	.....		.013	.33
30	.....		.012	.30

Table 5.—EXTENT TO WHICH INSERTED-POINT SAWTEETH AND TOOTH HOLDERS PRODUCED BY VARIOUS MANUFACTURERS OF SAWMILL SAWS CAN BE INTERCHANGED.*

Tooth and Holder Numbers in Same Vertical Column are Interchangeable

Manufacturer	Saw part	Manufacturer's part number																	
Atkins	Teeth	2	2½	3	3½	4	4½	5	B	C									
	Holders	2	2½	3	3½	4	4½	5	B.D.F.	C									
Corley	Teeth		2½	3						3D									
	Holders		2½	3					B.F.										
Disston	Teeth	4½D	2½	3	3½	8	4½	9		3D	ABC	ABC	ABC	1††	1††	1††		44	
	Holders	4½D	2½	3	3½	8	4½	9		3D	A	B	C	50	55	66		44	
Hoe	Teeth	2	2½	3	3½	4	4½	5	B	6								44	25
	Holders	2	2½	3	3½	4	4½	5	B.D.F.	6								44	25
Lippert	Teeth	2	2½	3															
	Holders	2	2½	3															
Simonds	Teeth	2	2½	3	3½	4	4½	5	B.D.F.†										
	Holders	2	2½	3	3½	4	4½	5	B.D.F.†										
Southern	Teeth	2	2½	3		4			B.F.	3D							1	2P	44
	Holders	2	2½	3		4			B.D.F.	3D							1	2P	44
Spear and Jackson	Teeth		2½	3	3½		4½		B										
	Holders		2½	3	3½		4½		B.D.F.										

*Adapted from U. S. D. A. Agricultural Handbook No. 27. Based on data furnished by manufacturers listed.
†B, D, or F teeth will fit either B, D, or F holders, but a saw milled for a given holder by the manufacturer must be fitted with that holder (holders not interchangeable.)
††Disston "Single Ball Invincible" tooth.

Table 6.—AVERAGE POWER REQUIREMENTS AT THE HEADSAW FOR SOME CANADIAN SPECIES. CARRIAGE SPEED, 170 FT./MIN.; SAW SPEED 700 R.P.M.*

Species	Depth of cut, inches						
	2	4	6	8	10	12	14
	Horsepower						
Balsam fir, Spruce	9	17	26	34	43	50	57
Basswood, White pine, Eastern hemlock, Red pine	10	20	29	39	49	59	68
Western hemlock, Jack pine	11	22	34	45	55	67	78
Douglas fir	13	26	37	50	62	74	87
Tamarack	13	27	40	54	67	80	94
White birch, Cherry, White elm	14	29	44	59	73	88	102
Black walnut, Yellow birch	16	33	48	65	79	95	111
Beech, Sugar maple	18	37	54	71	89	106	123
Rock elm, White oak	20	39	59	78	98	117	137

*Source: G. W. Andrews, "Sawing Wood with Circular Headsaws."

Note: Data obtained from investigations into the amount of power required to saw various species and the combination of saw and feed speeds which provide the most efficient use of power, conducted at the Ottawa Laboratory, Forest Products Laboratories of Canada.

The tests on power requirements were carried out at a saw speed of 700 r.p.m. and a carriage speed of 170 feet per minute and Table 6 summarizes the results to date.

Studies involving the most efficient use of power showed a saving may be obtained by reducing the r.p.m. of the headsaw, and maintaining the same feed rate. For example, a drop in saw speed of 300 r.p.m. instituted a saving of approximately 18% in power required. This feature is of particular value to a mill which is marginally or underpowered.

It was also shown that when a mill has ample power available, it is advantageous to use the maximum possible bite. The value of the increased production will more than offset the increased production cost due to power increase.

Table 7.—POWER REQUIREMENTS FOR EQUIPMENT OTHER THAN THE HEADSAW OF A SMALL MILL.*

Equipment item	Type	Horsepower required
Log haul	Car and inclined trackway, friction drive	6–10
	Gear drive	15–25
	Chain lift from sluice opposite deck	10–15
Log conveyor chains on deck		5–10
Log turners	Double-bar friction kickers	3–5
	Overhead shaft and chain, friction drive	6–10
	Single-bar type, friction drive	6–10
	Rocker-arm shaft type	15–20
Carriage drive	Heavy type	10–15
	Light or medium-weight type	5–10
Carriage setworks		3–5
Carriage dogs		1–2
Carriage log unloader		5–10
Sawdust chain		1–3
Sawdust blower		5–10
Refuse chain	Light type	5–10
	Heavy type	20–25
Live rolls		5–10
Transfer and conveyor chains		15–20
Sorter chains		5–10
Edger	Single-saw, manual type	5–10
	2- to 3-saw, 27-inch	15–20
	2- to 3-saw, 33-inch	20–25
	4-saw, heavy-duty	100
Two-saw trimmer		5–15
Cut-off saw		8–10
Slab cut-off saw		5–8

*Adapted from U.S.D.A. Agricultural Handbook No. 27.

Table 8.—MANUFACTURERS' APPROXIMATE HORSEPOWER RATING, PER INCH OF WIDTH, FOR STANDARD FLAT SAWMILL BELTS SUBJECT TO MEDIUM SHOCK LOADS, WHEN DISTANCE BETWEEN PULLEYS IS 15 FEET OR MORE.*

Belt speed (ft. per minute)	Leather belts		Rubber belts, per ply
	Single-ply	Double-ply	
	Horsepower	Horsepower	Horsepower
1,000	1.35	2.33	0.313
1,500	2.01	3.45	.474
2,000	2.62	4.50	.635
2,500	3.30	5.55	.797
3,000	3.90	6.54	.957
3,200	4.05	6.90	.965
3,400	4.27	7.26	.980
3,600	4.42	7.59	1.002
3,800	4.65	7.86	1.070
4,000	4.80	8.16	1.119
4,200	5.03	8.49	1.140
4,400	5.17	8.76	1.169
4,600	5.32	9.00	1.195
4,800	5.40	9.23	1.220
5,000	5.55	9.38	1.257

*Derived from data in catalogs of Chicago Belting Co. and Manhattan Rubber Co.
See Note following Table 9 for method of application.

Table 9.—MANUFACTURER'S HORSEPOWER RATING, PER BELT, OF FIVE TYPES OF STANDARD SAWMILL V-BELTS UNDER MILD SHOCK LOAD, WHEN ARC OF CONTACT IS 180°.*

	V-belt type A (½ by 11/32 inch)			V-belt type B (21/32 by 11/16 inch)			V-belt type C (7/8 by 17/32 inch)			V-belt type D (1¼ by ¾ inch)			V-belt type E (1½ by 1 inch)		
	Sheave pitch diameter			Sheave pitch diameter			Sheave pitch diameter			Sheave pitch diameter			Sheave pitch diameter		
Belt speed (ft. per min.)	3 inches Hp.	Change per inch diameter of pulley Hp.	5 inches Hp.	5 inches Hp.	Change per inch diameter of pulley Hp.	7 inches Hp.	9 inches Hp.	Change per inch diameter of pulley Hp.	12 inches Hp.	13 inches Hp.	Change per inch diameter of pulley Hp.	17 inches Hp.	22 inches Hp.	Change per inch diameter of pulley Hp.	28 inches Hp.
1,000	0.52	0.125	0.77	1.0	0.15	1.3	2.2	0.20	2.8	3.9	0.32	5.2	6.9	0.27	8.5
1,500	.75	.205	1.16	1.4	.25	1.9	3.2	.30	4.1	5.8	.50	7.8	10.2	.42	12.7
2,000	1.00	.27	1.54	1.8	.35	2.5	4.2	.40	5.4	7.5	.55	10.2	13.2	.57	16.6
2,500	1.16	.345	1.85	2.2	.40	3.0	5.1	.47	6.5	8.9	.85	12.3	16.0	.70	20.2
3,000	1.3	.40	2.1	2.5	.50	3.5	5.8	.57	7.5	10.2	1.02	14.3	18.5	.83	23.5
3,250	1.3	.45	2.2	2.5	.55	3.6	6.1	.60	7.9	10.7	1.07	15.0	19.3	.88	24.6
3,400	1.4	.45	2.3	2.6	.60	3.8	6.4	.67	8.5	11.1	1.12	15.6	20.1	.95	25.8
3,600	1.4	.50	2.4	2.6	.60	3.8	6.5	.70	8.6	11.4	1.20	16.2	20.8	1.00	26.8
3,800	1.4	.55	2.5	2.7	.65	4.0	6.8	.70	8.9	11.7	1.27	16.8	21.4	1.07	27.8
4,000	1.4	.55	2.5	2.7	.70	4.1	6.9	.77	9.2	11.9	1.35	17.3	21.9	1.12	28.6
4,200	1.4	.55	2.5	2.7	.75	4.2	7.1	.80	9.5	12.1	1.40	17.7	22.4	1.17	29.4
4,400	1.4	.60	2.6	2.7	.75	4.2	7.2	.83	9.7	12.2	1.47	18.1	22.7	1.23	30.1
4,600	1.3	.65	2.6	2.6	.80	4.2	7.2	.90	9.9	12.2	1.55	18.4	23.0	1.28	30.7
4,800	1.3	.65	2.6	2.6	.80	4.2	7.3	.97	10.2	12.2	1.60	18.6	23.1	1.35	31.2
5,000	1.2	.70	2.6	2.5	.85	4.2	7.3	.93	10.1	12.0	1.70	18.8	23.2	1.38	31.5

*Adapted from U.S.D.A. Agricultural Handbook No. 27. Derived from data in catalog of L. H. Gilmer Co., Tacony, Philadelphia, Pa.

Note: The values given in Tables 8 and 9 are for transmission between pulleys of equal size. If one pulley is smaller than the other, as often happens in order to step up or reduce speeds, the ratings must be multiplied by a reduction factor that in turn depends on the arc of contact between the belt and the smaller pulley. This arc will be less than 180°; it represents a convenient way of expressing the reduced area of surface contact between belt and pulley. Since this arc is smaller with smaller pulleys, less power will be transmitted to or from the smaller pulley.

The arc of contact of the smaller pulley can be calculated by a simple formula:

$$\text{Arc of contact} = 180° - \frac{(D-d)\ 57}{\text{Distance between pulley centers (inches)}}$$

Where D is the diameter of the larger pulley in inches, and d is that of the smaller pulley.

When the arc of contact of the smaller pulley for a given hook-up is found by this formula, the reduction factor used with values in Table 8 for flat belts will be:

Arc of contact	Reduction factor
170°	0.95
160°	.90
150°	.85
140°	.80

Similarly, the reduction factors used with values in Table 9 for V-belts on pulleys of dissimilar sizes are:

Arc of contact	Reduction factor
170°	0.98
160°	.95
150°	.92
140°	.89
130°	.86
120°	.82
110°	.77
100°	.72

Properties, Uses, and Production of Engelmann Spruce[1]

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A beetle epidemic in the northern Rocky Mountain area accelerated the marketing of Engelmann spruce. Utilization studies revealed that it is a versatile species, suitable for specialty items, construction uses, millwork, ties, mine timbers, and pulp and paper. Data were developed on lumber grade recovery, and lumber yield from trees of different ages, site classes, and degrees of stocking.

ALL OVER-RIPE VIRGIN FORESTS eventually become victims of disease and insects if the timber is not logged. Such a fate occurred in the overmature Engelmann spruce forests of the northern Rocky mountain area in 1951. A vast *Dendroctonus* beetle population was bred in wind-thrown spruce uprooted in 1949 and 1950. During its first year, the infestation took a toll of over 600 million board feet of spruce timber throughout western Montana and northern Idaho. It was soon evident that this epidemic could not be controlled by any ordinary method such a spraying. A task force comprised of representative of the lumber industry and public agencies decided that control through utilization was the only means to salvage the timber.

Prior to that time, annual production of Engelmann spruce lumber in the northern Rocky mountain area[2] had never exceeded 35 million feet. The first year after the big flight of beetles, over 300 million feet of logs were moved. During the summer of 1954 and winter of 1954–1955, this was increased to approximately 440 million. And during the summer of 1955 and the winter of 1955–1956, it was expected that approximately 500 million feet of Engelmann spruce would be logged (10).[3] It is hoped that this large-scale removal of timber from infested areas will control the epidemic by the end of 1956.

By focusing the spotlight on salvage of insect-killed Engelmann spruce, a vast backlog of information has been developed on utilization of the species. A special committee on utilization of Engelmann spruce was formed and worked under the guidance of the emergency salvage task force. Information was developed on lumber grade recovery of Engelmann spruce as indicated by shipping records. A number of mill scale studies were made to determine the yield of lumber from Engelmann spruce of different ages, site classes, and degrees of stocking.

[1] Presented at meeting of FPRS Inland Empire Section August 4–5, 1955, in Butte, Mont.

[2] Western Montana, Idaho north of the Salmon River, and eastern Washington.

[3] Numbers in parentheses refer to literature cited.

The Author: I. V. Anderson joined the U. S. Forest Service in 1920 after graduating from Michigan State College. He served as ranger, forest examiner, assistant forest supervisor, specialist in forest products research, chief of wildlife management, and was chief of forest utilization service at the Intermountain station prior to his retirement in 1955. Anderson, a charter member of FPRS, is author of numerous publications on logging and utilization.

Fig. 1.—Engelmann spruce logs are light and straight so loads of 10,000 feet per truckload are common.

Table 1.—SOME MECHANICAL PROPERTIES OF ENGELMANN SPRUCE COMPARED TO OTHER WOODS.*

Species	Modulus of Rupture (psi)	Fiber Stress at Proportional Limit (psi)	Hardness†† End	Hardness†† Side	Weight per Cubic Foot (lbs.)
Engelmann spruce	8700	5500	560	350	23.7
Western red cedar	7700	5300	660	350	23.1
White fir†	9800	6300	770	470	26.6
Lodgepole pine	9400	6700	530	480	28.7
Western white pine	9500	6200	440	370	26.6
Ponderosa pine	9200	6300	550	450	27.9

*All data computed at 12% moisture content.
†Average for grand fir (*Abies grandis*), California red fir (*A. magnifica*), and white fir (*A. concolor*).
††Load required to imbed a 0.444 inch ball to half its diameter.

Studies of utilization practices in the woods were made and included recommendations for log trimming allowance needed under different methods of logging Engelmann spruce (2).

The aid of the U. S. Forest Products Laboratory in Madison, Wis. was also enlisted. This laboratory produced and circulated reports on: use of Engelmann spruce for house construction, mechanical and machining properties of the species, kiln- and air-drying of Engelmann spruce lumber, and its value for pulp and paper products, ties, mine timbers, and veneer and plywood. These data are so voluminous that only a brief digest can be presented in this paper.

Properties and Uses

Englemann spruce is a versatile wood and finds a ready market for a host of uses, ranging from rough construction to fine interior finish and specialty products. Although it is a very light wood, it has a high strength-weight ratio which fits it for specialty uses. It is interesting to compare some of its mechanical properties with other softwood species marketed from the same producing area (11).

Mechanical Properties

Engelmann spruce is one of the lightest important commercial woods of the United States. With the exception of western red cedar, it is the lightest wood marketed from the Inland Empire area. Table 1 shows that it weighs 23.7 pounds per cubic foot, compared to 23.1 pounds for western red cedar.

In spite of its light weight, Engelmann spruce is appreciably stronger than western red cedar. Table 1 indicates a modulus of rupture of 8,700 pounds per square inch for spruce as compared to 7,700 pounds for cedar.

The fact that this wood is lighter and somewhat weaker than many of the commonly used construction woods does not mean that it cannot be used where strength is required. For instance, in house construction 2 x 4-inch studs of Engelmann spruce at the usual 16-inch spacing will meet all requirements. Likewise, the strength of the species is entirely adequate to permit its use in ordinary 1-inch lumber for wall, roof sheathing, subflooring, and similar uses.

In most of its strength properties, Engelmann spruce is comparable to ponderosa pine. Its stiffness rating is practically the same as ponderosa pine, and its volumetric shrinkage is less than pine. Due to this similarity of properties, Engelmann spruce is now being used interchangeably in many cases for ponderosa pine.

Machining Properties

Ponderosa pine and Douglas-fir are two of the principal species now being used for millwork items. Thus, it is appropriate to compare the machining of Engelmann spruce with these two species. In recent tests, spruce was somewhat below ponderosa pine in machining properties but somewhat better than Douglas-fir (3). It was concluded that if proper precautions are taken, the machining properties of Engelmann spruce are adequate for all ordinary uses.

Planning tests were made of Engelmann spruce with a modern molder having a 4-knife cutterhead with a 6½-inch cutting circle. It was found, under the test conditions used, that Engelmann spruce was intermediate between ponderosa pine and Douglas-fir. The most common defects developed in spruce were fuzzy and raised grain. Raising of the grain was easily corrected if the boards were seasoned to the proper moisture content. Most of the spruce lumber shipped from the Inland Empire has a moisture content of about 12 per cent and consequently contains a minimum amount of fuzziness.

Engelmann spruce works well on the shaper. Little difficulty was encountered in tests with side grain cuts and only a moderate amount of tear-outs occurred on end grain cuts. Tests also showed that Engelmann spruce was intermediate between ponderosa pine and Douglas-fir in turning on a lathe and was considered satisfactory for this purpose.

Seasoning Properties

About three-fourths of the Engelmann spruce lumber produced in this area is kiln-dried and the balance air-seasoned. Most operators now follow the practice of sorting for thickness, sap and heart stock, common and select grades. Sapwood in Engelmann spruce frequently has a moisture content of 150 per cent contrasting to less than 50 per cent in the heartwood, so the reason for separating these two classes of stock is obvious. However, the sapwood of logs from insect-killed trees loses its moisture rapidly and has been found in many instances to be about the same moisture content as heartwood, so that many operators do not separate sap from heart, particularly in two-year-old insect-killed timber.

There are no particularly troublesome problems in kiln drying of Engelmann spruce lumber whether thick or thin (7). Drying schedules are available giving the detail of drying 4/4 select and common lumber. One operator has worked out a schedule that is particularly suitable for protection of knots; 8/4 sap and heart boards can also be kiln-dried with a minimum of seasoning defect.

About 25 per cent of the Engelmann spruce lumber now being produced is air seasoned. Considerable face-checking and end splits may develop if air drying time is accelerated (6). During the hot weather of July, August, and September, it is possible to dry 4/4 spruce lumber to a moisture content of 12 to 14 per cent in 10 to 20 days. However, this is not considered advisable since a great deal of

seasoning defect develops. It is better to increase the drying time to at least 30 days by decreasing pile height, providing pile roofs, and manipulation of other factors such as pile spacing, flues, chimneys, etc. For instance, it is generally considered that placing stickers flush with the ends of the boards reduces the amount of end checking.

Preservative Treatment

Although Engelmann spruce is sometimes considered difficult to treat, it has been treated commercially on a successful basis for many years. For instance, Engelmann spruce railway ties that have been carefully pressure treated with creosote or creosote-oil solutions have given an average service life of from 25 to 29 years (9). Information available indicates that air-seasoned Engelmann spruce takes oil treatment better than retort-seasoned material. Optimum treating temperatures are 190° to 200° F. when impregnating with creosote or creosote-oil solutions.

Specialty Uses

Because of its high strength-weight ratio, Engelmann spruce was rated as suitable for aircraft construction during both World Wars. For years it has been a choice wood for making high-grade violins due to its resonant character, and is highly prized for the manufacture of other musical instruments, including pianos. It is also used for paneling interior finish, kitchen furniture, ironing boards, step-ladders, and similar products.

Used for Ties and Mine Timbers

This species has been used for many years in the central Rocky Mountain area for mine timbers and cross ties. Woods used for ties should be hard and give good bending and compressive strength. These properties are so combined in Engelmann spruce that this species is considered only slightly less suitable for ties than ponderosa pine, lodgepole pine, and woods of similar properties. If placed on good ballast and protected by tie plates, treated Engelmann spruce ties give good service.

Although Engelmann spruce does not have bending and compressive strength comparable to some of the other species commonly used for mine timbers, such as western larch and Douglas-fir, it gives satisfactory service for this use. L. W. Wood and J. O. Blew have indicated that "Tests of Rocky Mountain mine timbers showed that the grade factor often overshadowed the effect of species, so that little difference in strength was observed between Engelmann spruce and other species" (9). Engelmann spruce timbers have given satisfactory service in mining in Colorado and Wyoming.

Table 2.—TYPICAL YIELDS PER CORD OBTAINED IN PULPING ENGELMANN SPRUCE.*

Sulfate pulps†	
Yield unbleached kraft	940–1020 pounds
Yield bleached kraft	855 pounds
Sulfite pulps†	
Yield unbleached pulp	980 pounds
Yield bleached pulp	920 pounds
Groundwood pulp†	
Yield of pulp	1970 pounds

*Wood weighed 20 pounds per cubic foot, oven dry weight and green volume basis.
†Basis air dry pulp—not adjusted for loss from barking, sawing, and mill effluent of commercial operation.

Suitability for Pulp and Paper

Even though Engelmann spruce has not been widely used for pulp and papermaking to date, the paper industry regards it highly for papermaking. It has long fiber, a relatively light color, and an absence of resionus substances, all of which make it readily pulped by the sulfite, sulfate, and groundwood processes. While Engelmann spruce is somewhat lower in density than white and black spruces commonly used in the eastern paper industry, its lower density is offset to a great extent by a relatively high solid volume of wood per cord resulting from its thin bark and straightness. Its yield of pulp on a cord basis is comparable to the other spruces.

It has been determined that dead Engelmann spruce trees killed by the *Dendroctonus* beetle are satisfactory for papermaking if salvaged before extensive decay takes place. Surveys to date have indicated that on many sites of the Engelmann spruce forests of the northern Rocky Mountain areas, insect-killed spruce trees will remain suitable for pulp and papermaking for as long as 15 years. It is hoped that much of the timber killed in recent years that has not been salvaged for lumber will be used for pulp and paper.

High-grade newsprint is being made from Engelmann spruce and excellent quality book papers are also being produced. The strength and brightness of papers made from Engelmann spruce are above average.

Table 2 gives typical yields obtained from Engelmann spruce when pulped by three different methods. For instance, the yield of groundwood pulp is 1,970 pounds per cord of wood used (8), which is a rather high yield.

Use for Home Construction

Homebuilders are using a large share of the Engelmann spruce lumber being produced today. For this purpose it can be used interchangeably with such western woods as ponderosa pine, sugar pine, Idaho white pine, western red cedar, and white fir. It has many properties that make it desirable to the homebuilder (5). In nail holding properties it is classed with ponderosa pine and white fir. It is classified as a low-shrinkage wood, and at identical moisture content it behaves about the same as ponderosa pine. It is also relatively free from warping, light in weight, and easy to work.

It is a uniformly white wood that has a pleasing knot pattern and a rather even distribution of small sound knots, so is adaptable for use as interior wall paneling. Other uses in the house are for exterior trim, roof boards, sidings, wall sheathing, shelving, subflooring, and framing.

Since it is somewhat low in strength properties compared to woods like Douglas-fir, this must be taken into consideration when it is used for floor joists and roof rafters. Shorter spans can be used and if that is not practical, size of joists can be increased to compensate for the strength deficiency. However, Engelmann spruce can be used in the same stud size as any of the heavier and stronger species.

It is also practical to use Engelmann spruce for floor and roof decking in house construction. It is believed that material of 2 and better common grade that is tongue and grooved, 4 inches thick, 5 inches wide, and end jointed will make satisfactory roof and floor decking that will meet any normal strength requirement in home construction. This will be true, of course, provided the span is compatible with good framing requirements.

Veneer and Plywood

Normally the Engelmann spruce boles do not have much clear length and the clear wood is not very deep radially. Thus, it does not appear practical to consider Engelmann spruce as a source of peeler stock throughout its production range. However, it is considered as an excellent wood for production of slicing cants. Informed individuals have estimated that at least 50 million feet of slicing cants could be produced in the northern Rocky Mountain area. It is estimated that 1 million feet of cants makes from 6 to 8 million square feet of knotty plywood panel, so a sizable industry could be built on Engelmann spruce for this class of plywood.

Lumber Quality

The emergency utilization of spruce as a *Dendroctonus* beetle control measure has stimulated studies in the quality of Engelmann spruce lumber produced from stands of varying characteristics (2). Studies were, of course,

primarily directed toward learning the extent of depreciation due to insect infestation. Particular emphasis was placed on the rate of deterioration of the timber. Considerable information was developed on lumber grade recoveries for Engelmann spruce trees one, two and three years after being struck by beetles.

Considerably more tree and log quality information was secured in connection with these spruce depreciation studies. For instance, it was found that age, site, and degree of stocking have a significant effect on lumber grade recoveries and materially influence the value of the lumber produced from a stand.

Naturally, as an Engelmann spruce tree grows in size and age, it also grows in value of the lumber produced. On good, well-stocked sites, Engelmann spruce trees were noted that had developed as much as 2 and 3 logs clear length in the butt portion of the tree (Fig. 2). These trees produced a high percentage of D and better select lumber. However, as the trees grow older, more defect develops and this often eliminates or at least neutralizes the effect of age on quality of lumber produced.

Fig. 2.—Over-mature Engelmann spruce trees sometimes produce two or three surface-clear logs.

Practically all grade recovery studies were confined to over-mature old growth timber. This ranges in age from 225 to 300 years of age. Like Idaho white pine, Engelmann spruce is also considered old or over-mature at this age. The influence of age on Engelmann spruce is also similar to that on Idaho white pine.

Sites of old, over-mature timber were classified in accordance with forest survey standards of the U. S. Forest Service in good, medium, and poor sites. Table 3 gives a comparison of the lumber recovery for these three sites. It was found that lumber recovery from poor sites in this over-mature type of timber was only 84 per cent as valuable as the lumber produced from trees on good sites.

For several reasons, classification of Engelmann spruce timber by sites and age is probably a more practical way of quality appraisal than individual tree or log appraisal. First, Engelmann spruce trees on the better sites are often 8 or 9 logs in height. It would be difficult to ascertain the character of the logs 4 or 5 logs high in the tree. It is possible, however, to determine the general quality of the tree by the first 2 or 3 logs, but the process is much more time consuming than classification by site and age.

In Table 3 it will be noted that the good site produced 20 per cent of D and better select lumber. The stand was considered well stocked and contained a volume of 20 to 25,000 feeet per acre. Slightly over 30 per cent of the volume of the study was from trees having 1 clear log, while 6 per cent of the volume of the trees had 2 clear logs. The medium site class only produced lumber having 7 per cent D and better select. Here only 3 per cent of the volume of the study trees had 1 or more clear logs contrasted to 37 per cent for the trees in the study classed as a good site. Thus, it is evident that clear length plays an important part in grade recovery.

If quality appraisal were being attempted on a small area containing only a few acres, classification or grading on a tree basis would no doubt be necessary. However, where 40 acres or more of each classification are involved, it is believed that sufficiently accurate information can be obtained on lumber quality by using the site classification method of appraisal combined with age and adjusted for any unusual defect factor.

If data similar to that in Table 3 were available on Engelman spruce stands at rotation age (120 years) and somewhat below rotation age (90 years) it would be complete enough for accurate quality appraisals of Engelmann spruce stands throughout the Rocky Mountain area. Little information is available on grade recoveries of Engelmann spruce timber at 120 years of age or less, but indications are that yields as high as 60 per cent of 1 and 2 common lumber can be expected from this age of timber. Quality also should be more uniform in these younger age classes since they are less affected by defect and other mortality and depreciation factors. A high recovery of No. 1 and 2 common will also tend to bring these stands up to that of the older and over-mature timber in value. Smallness of size will be a penalizing factor, however, because small timber costs more to log as well as to manufacture into lumber in the sawmill.

A composite of the grade recoveries of Engelmann spruce is indicated by average shipments of one of the older operators in the northern Rocky Mountain area. Table 4 presents this information which shows that about 7 per cent of D and better select lumber were shipped. This is somewhat below production of Idaho white pine selects but the production of 1 and 2 common and 3 common are practically the same. Likewise as in Idaho white pine, the higher common grades carry the bulk of the value in Engelmann spruce lumber. Of course, this is an exception in the old over-mature stands grown on the better sites.

Production and Available Volume

Due to the chaotic conditions created by the spruce bark beetle epidemic, present figures on the remaining volume of Engelmann spruce lumber are not accurate. There is good assurance, however, that a substantial volume of Engelmann spruce lumber remains in the forest of the Rocky Mountain area, and Engelmann spruce lumber will be on the market for many years in the future.

Spruce is the dominant species on about 730,000 acres of commercial forest land of all ownership in this area. It is widely distributed in other timber types and is one of the faster growing trees, so apprehension over

Table 3.—COMPARISON OF LUMBER RECOVERY AND ESTIMATED LUMBER VALUE OF OVERMATURE ENGELMANN SPRUCE STANDS ON GOOD, MEDIUM, AND POOR SITES.*

Site Class	Select D and Better Per cent	Common		Total 3 Com. and Better Per cent	Common		Selling Value† Per cent
		1 and 2 Per cent	3 Per cent		4 Per cent	5 Per cent	
Good	20	18	35	73	20	7	100
Medium	7	28	38	73	22	5	93
Poor	2	20	40	62	30	8	84

*Site classification based upon forest survey standards of U. S. Forest Service.
†Selling values converted to percentage basis using value of lumber from the good site as 100 per cent

its future supply is unnecessary provided good management practices are continued. About 78 per cent of the spruce volume is contained on national forest land where allowable annual cuts are developed by working circles. Conservative estimates indicate that at least 250 million board feet of spruce lumber can be produced annually for an indefinite period from the northern Rocky Mountain area alone.

Many of the spruce stands today are old growth and over-mature. They are being rapidly opened up with new utilization roads and, as logging progresses, more slash is created and greater insect risks develop than existed before, so the remaining virgin stands are still vulnerable to insect attack and natural decadence. As roads make timber areas accessible for current logging, trees that may be infested in the future can be logged before deterioration takes place. Market conditions of the future will also influence the annual cut of Engelmann spruce to a certain extent. The foregoing statements apply to only the northern Rocky Mountain area, including Montana, northern Idaho, and eastern Washington.

Engelmann spruce is also found in substantial commercial quantities in Colorado, Utah, and Wyoming. New mills are becoming established in these areas, which will accelerate spruce lumber production. Considering these facts and the trends occurring in the production of other western softwood species, it is estimated that the total production of Engelmann spruce lumber throughout the entire range of the species will vary between 300 and 500 million feet per year between now and 1975, depending upon the market and the incidence of insects, disease, and fire.

Due to the beetle epidemic, the future cut will be somewhat erratic geographically, since some localities have suffered much greater damage than others. This erratic pattern of damage will be reflected for the next half a rotation, or probably the next 50 years, in that some communities that previously produced small amounts of Engelmann spruce will be producing much more than others because the remaining spruce supply is closer at hand.

Summary

The beetle epidemic in Engelmann spruce has accelerated the marketing of this species. It is expected that Engelmann spruce lumber will now assume its place with such other softwood species as Idaho white pine, white fir, western larch, and ponderosa pine in the lumber economy of the West.

It is a most versatile species, being used for such specialties as violins, and is also finding wide use as a house construction lumber. Probably the greatest competition with lumber will come from its use in pulp and paper. It will also continue to supply the small knotted type of common board in competition with ponderosa pine and Idaho white pine.

As the more remote areas of Engelmann spruce are opened up for utilization, it is expected that the quality of lumber production will also include greater volumes of select grades. There are no appreciable areas of young or rotation-age Engelmann spruce in the region and it presumably will be 50 years before production of this class of material is a significant factor on the lumber market. Engelmann spruce lumber production will probably exceed 300 million feet annually between now and 1975, and substantial volumes of insect-killed spruce will be salvaged for pulpwood.

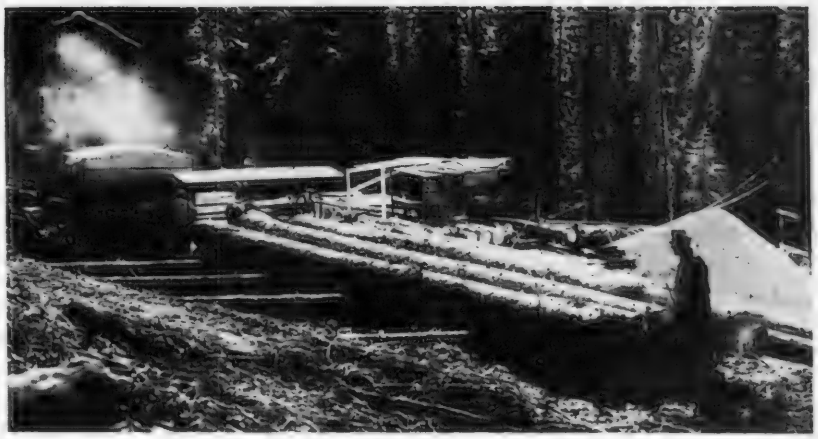

Fig. 3.—Selective cutting of insect-infested trees is sometimes done by small mill operations.

Table 4.—PERCENTAGE OF GRADES OF ENGELMANN SPRUCE LUMBER SHIPPED BY AN AVERAGE SPRUCE PRODUCER DURING THREE-YEAR PERIOD.

Grade	Per cent
D and Better Select	7.0
1 and 2 Common	24.5
3 Common	36.2
4 Common	16.3
5 Common	6.8
Shorts	7.8
Other	1.4

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Swelling of Paint Films in Water
VIII. Swelling of Linseed Oil Paints in Water and Organic Liquids

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Compares the swelling effect of water and five organic liquids on films of unbodied linseed oil and of five linseed oil paints. All of the oil and paint films absorb, swell, and lose soluble ingredients in the organic liquids in much the same manner as they do in water. The order of increasing swelling power is nearly the same for all films, both before and after weathering artificially.

PREVIOUS PAPERS in this series (1)[2] have discussed the swelling of paint films and coatings in water. Of course, water is the swelling liquid of chief practical interest, but comparison of water with other liquid swelling agents should throw further light on the mechanism of swelling. Concern with swelling by organic liquids for paint removers (2) was not an immediate object of this work.

Swelling Liquids

Liquids were chosen whose relative capacity for swelling wood has been given by Stamm (6) as follows:

Liquid	Swelling relative to water Per cent
Water	100
Ethyl alcohol	83
Dioxane	62
n-Butyl alcohol	13.5
Benzol	0

Mineral spirits, which does not swell wood, was added to the list because of its common use as a paint thinner. The ethyl alcohol, butyl alcohol, and benzol were anhydrous, and of chemically pure grade. The dioxane was dehydrated and freed from peroxide by treatment with metallic sodium and redistillation. The water was distilled.

The density of distilled water at the temperature of the laboratory was considered to be 1.000, which is within the limits of accuracy required for the experiments. The specific graviy of the other swelling liquids was found by test to be:

Ethyl alcohol	0.790
Dioxane	1.035
Butyl alcohol	.812
Benzol	.878
Mineral spirits	.782

A few liquids swell wood more than water does. They are formic acid, compounds related to pyridine and morpholine, and some amines. A preliminary test showed that morpholine swells white lead linseed oil paint greatly, but makes a slimy film much too difficult to handle in the testing procedure, and it causes zinc oxide paint to disintegrate. Use of so highly acid a substance as formic acid was considered undesirable.

Preliminary tests also showed that dioxane and ethylene glycol monobutyl ether swell paint films markedly, but when the films are redried, much of the absorbed liquid is retained for a long time. The retained swelling liquid, however, can be removed by soaking the redried films in distilled water for three days and then redrying them.

Paint Films and Test Methods

Free films were made of unbodied linseed oil containing a lead-manganese paint drier, and of each of five linseed oil paints, all with a 30 per cent pigment volume, as follows: basic carbonate white lead, paint L; zinc oxide, paint Z; rutile titanium dioxide, paint T; white lead and zinc oxide, paint LZ_{25}; and titanium dioxide and zinc oxide, paint TZ_{25}. The subscript is the percentage of zinc oxide in the total pigment volume.

The paint films to be tested before weathering were spread on gummed paper by doctor blade and suction plate. The linseed oil was spread by brushing. The films were allowed to dry for 10 days and were then stripped from the gummed paper, cut into specimens 1½ by 2½ inches in size, marked with reference lines for measurement of length and width, and dessicated over calcium chloride. The films for tests in water and in mineral spirits were 19 days old when immersed in the swelling liquid; those for ethyl alcohol and benzol were 22 days old, and those for butyl alcohol and dioxane were 23 days old.

Weathered films were made by spreading the paints on tinplate. They were allowed to dry for 10 days, and then exposed in a weatherometer to ultraviolet light from a flaming carbon arc with a Corex D glass filter and sprayed three times an hour with distilled water for 15 days. After the artificial weathering, the films were stripped by amalgamation of the tin, cut to size, marked, and dessicated for testing.

Swelling tests were made as follows: the length and width of the film between reference marks were measured with a traveling microscope. The film was weighed first in air and then under distilled water to obtain the volume by displacement. After the water left on the surface from the brief immersion had evaporated, the film was submerged between two pieces of coarse-meshed glass cloth in 250 cubic centimeters of swelling fluid in a crystallizing dish. The glass cloth was weighted, and the dish was covered with a watch glass and sealed to prevent evaporation of the swelling liquid. The sealed dish was then placed in a water thermostat at 70° F. for three days.

After the film had soaked for three days, it was removed and immediately weighed under a fresh supply of the swelling liquid. The length and width between reference marks on the swollen film were measured with the film sandwiched between glass microscope slides. The film was then blotted quickly to remove excess swelling liquid from the surfaces, placed in a tared bottle, and weighed to determine the weight of the swollen film in air.

A few films were found to be too fragile when swollen to be straightened out between glass slides for the

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Numbers in parentheses refer to literature cited.

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measurement of length and width. These films were then redried first in the laboratory and finally in a desiccator over calcium chloride. The redried film was then weighed in air. If the film remained reasonably flat or was tough and flexible enough to be held flat between microscope slides, the length and width between reference marks were measured. Some films, however, were too badly curled and too fragile to be handled in that way. In such cases, the curled edges of the film were cut off so that, if possible, the marked central portion of the film was left in suitable condition for the measurement of length and width. The sample so cut down was then weighed in air and under water, and its density was calculated. From the density and the weight in air of the uncut film, the volume of the whole redried film could be calculated. Even when redried films were too fragile to be measured, it was always possible to recover sufficient fragments for a determination of density and therefore of the volume of the redried film.

All films that were soaked in dioxane and redried were then soaked in water for three days to remove the retained dioxane. They were then weighed in air, measured, and weighed under water. The results are tabulated for the swelling liquid "dioxane, then water."

Results were calculated by the methods described in the sixth paper in this series (1) with due allowance for the specific gravity of swelling liquids other than water. Thus the volume of a swollen film, V_s, was determined by dividing the displacement of the swelling liquid in grams by the specific gravity of the liquid. Likewise, the absorption of a swelling liquid was calculated in cubic centimeters by dividing the absorption in grams by the specific gravity of the liquid. Solubility of the film was expressed in grams of material lost per 100 cubic centimeters of initial volume of film, since the specific gravity of the dissolved material is unknown. Some films that gained in weight when soaked in dioxane and then redried are reported in the tables with positive (+) change in weight from initial to redried conditions.

Results with Unweathered Films

Results with unweathered films are reported in Table 1.

Linseed Oil without Pigment: The amount of liquid absorbed by films of unpigmented linseed oil ranged from 11.8 per cent for water to 410 per cent for dioxane. Volumetric swelling was equal or nearly equal to the volume of liquid absorbed. Swelling efficiencies varied from 95 per cent in butyl alcohol to 101 per cent in water. Thus swelling and redrying produced little or no porosity in the films, except perhaps very slighly with butyl alcohol. When the films swelled, their density decreased roughly in proportion to the amount of swelling liquid absorbed, but it was regained or in-

Table 1.—BEFORE WEATHERING—ABSORPTION, SWELLING, AND RELATED DATA FOR FREE FILMS OF UNBODIED LINSEED OIL AND LINSEED OIL PAINTS WHEN SOAKED IN DIFFERENT LIQUIDS FOR THREE DAYS AND THEN REDRIED.

Paint	Swelling liquid	Density			Initial thickness	Absorption of liquid	Swelling			Swelling efficiency	Redried			Weight change from initial to redried condition
		Dry	Swollen	Redried	T_o	A/V_o	In volume ΔV_s	In area ΔQ_s	In thickness ΔT_s	$\frac{\Delta V_s V_o}{A}$	Volume ΔV_r	Area ΔQ_r	Thickness ΔT_r	S_2/V_o
					Mils	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Gm. per 100 cc.
Linseed oil	Water	1.09	1.08	1.09	9.0	11.8	11.9	3.6	8.3	101	-3.0	-0.8	-2.2	-2.8
	Ethyl alcohol	1.10	.96	1.12	7.8	59.0	57.6	49.5	15.6	98	-46.8	-33.5	-19.6	-50.8
	Butyl alcohol	1.11	.93	1.11	7.4	104	99.4	(1)	.....	95	-49.8	(1)	.....	-55.5
	Dioxane	1.11	1.04	1.09	8.2	407	407	(1)	.....	100	-40.7	(1)	.....	-46.0
	Dioxane, then water	.....	.....	1.11	.....	410	410	(1)	.....	100	-43.5	(1)	.....	-48.2
	Benzol	1.10	.98	1.10	8.9	109	107	58.1	42.6	98	-33.0	-16.2	-20.0	-36.3
	Mineral spirits	1.10	1.03	1.10	8.0	31.0	30.1	13.4	15.3	97	-5.3	-2.8	-2.0	-5.9
White lead L	Water	2.89	2.79	2.93	4.0	7.7	7.6	2.1	6.5	99	-2.4	-0.3	-1.5	-3.4
	Ethyl alcohol	2.90	2.74	3.34	4.0	28.5	26.0	10.1	16.6	91	-19.7	-4.8	-15.7	-22.7
	Butyl alcohol	2.87	2.42	3.34	4.0	48.5	46.2	14.0	32.2	95	-21.4	-4.8	-17.3	-24.0
	Dioxane	2.92	1.71	3.20	4.0	197	194	69.1	78.3	98	-15.9	+13.4	-25.3	-21.9
	Dioxane, then water	.....	.....	3.31	.....	203	198	71.9	80.0	98	-20.0	+10.6	-27.0	-26.8
	Benzol	2.89	2.36	3.31	4.0	53.9	52.3	20.2	30.7	97	-18.9	-3.8	-15.9	-20.4
	Mineral spirits	2.89	2.66	3.03	4.0	17.8	17.8	5.2	12.7	100	-6.4	-1.5	-4.9	-6.1
Titanium dioxide T	Water	2.06	1.87	2.10	4.3	26.4	26.4	9.5	15.6	100	-3.5	+1.2	-4.6	-3.5
	Ethyl alcohol	2.08	2.03	2.27	4.1	30.8	17.1	13.6	9.7	56	-23.8	-8.8	-16.5	-35.4
	Butyl alcohol	2.08	1.83	2.28	4.0	50.3	40.1	24.4	17.7	80	-25.2	-10.8	-15.7	-37.7
	Dioxane	2.08	1.40	2.26	4.1	208	202	(1)	.....	97	-20.9	(1)	.....	-29.4
	Dioxane, then water	.....	.....	2.33	.....	210	205	(1)	.....	98	-24.1	(1)	.....	-31.7
	Benzol	2.07	1.92	2.26	4.1	34.4	30.0	16.4	11.4	87	-19.9	(1)	.....	-26.0
	Mineral spirits	2.07	2.00	2.17	4.0	12.9	12.9	10.9	2.0	100	-8.3	-5.9	-2.0	-8.6
Zinc oxide Z	Water	2.49	2.00	2.51	3.8	51.2	50.3	11.8	34.0	98	-3.1	+4.9	-8.5	-5.9
	Ethyl alcohol	2.50	2.34	2.65	3.6	25.4	20.1	14.9	5.7	79	-13.4	-9.6	-4.1	-20.2
	Butyl alcohol	2.50	2.07	2.67	3.7	56.0	45.8	21.0	23.5	82	-16.9	-9.2	-8.1	-28.1
	Dioxane	2.50	1.81	1.39	3.7	182	143	59.0	52.1	78	+158	+58.0	+62.6	+104.4
	Dioxane, then water	.....	.....	1.95	.....	313	184	67.6	87.5	59	-41.0	-8.5	-35.4	-136
	Benzol	2.50	2.11	2.44	3.8	45.3	33.3	29.3	3.1	74	-4.0	-3.4	-1.0	-15.7
	Mineral spirits	2.50	2.28	2.57	3.8	20.4	19.4	5.7	10.8	95	-4.9	-2.6	-2.3	-4.9
Lead-zinc LZ_{25}	Water	2.77	2.38	2.79	3.8	29.8	29.4	5.8	21.6	99	-2.2	+3.2	-5.2	-4.0
	Ethyl alcohol	2.79	2.57	3.17	3.9	30.5	28.5	10.9	18.3	93	-18.7	-5.7	-13.7	-22.0
	Butyl alcohol	2.79	2.30	3.18	3.9	51.0	48.6	16.1	31.6	95	-19.5	-5.4	-15.1	-23.1
	Dioxane	2.79	1.77	1.86	3.9	149	149	67.2	49.2	100	+53.9	+45.0	+6.1	+7.1
	Dioxane, then water	.....	.....	2.51	.....	214	161	39.6	88.7	75	-11.9	+27.6	-39.3	-57.7
	Benzol	2.78	2.18	3.06	4.0	59.2	58.0	21.2	33.4	98	-14.2	-1.5	-12.7	-14.8
	Mineral spirits	2.77	2.53	2.89	3.9	20.1	19.5	6.0	14.0	97	-6.1	-1.3	-5.0	-6.0
Titanium-zinc TZ_{25}	Water	2.18	1.72	2.18	4.1	62.5	61.9	19.8	34.0	99	-2.1	+11.3	-11.7	-4.8
	Ethyl alcohol	2.19	2.06	2.42	4.0	30.7	25.4	17.6	9.2	83	-21.5	-10.0	-13.2	-29.1
	Butyl alcohol	2.20	1.81	2.42	4.0	54.2	47.7	26.4	21.3	88	-21.8	-10.0	-13.4	-30.6
	Dioxane	2.18	1.60	1.57	4.2	117	121	73.6	27.4	103	+48.0	(1)	.....	+15.3
	Dioxane, then water	.....	.....	1.75	.....	195	134	74.2	27.1	69	-12.9	(1)	.....	-65.3
	Benzol	2.18	1.76	2.34	4.1	61.5	59.0	28.4	13.6	96	-13.1	(1)	.....	-15.7
	Mineral spirits	2.17	2.02	2.24	4.2	18.1	17.8	10.7	5.7	99	-5.7	-4.2	-.9	-5.3

(1) Film too fragile to measure.

Table 2.—LIQUIDS ARRANGED IN THE ORDER OF THEIR VOLUMETRIC SWELLING OF WOOD AND OF UNWEATHERED AND WEATHERED FILMS OF EACH KIND OF OIL OR PAINT TESTED.

Material swollen	Liquids* in order of increasing swelling, left to right					
Unweathered Films						
Clear linseed oil	Water	Min. sp.	EtOH	BuOH	Benzol	Dioxane
White lead	Water	Min. sp.	EtOH	BuOH	Benzol	Dioxane
Titanium dioxide		Min. sp.	EtOH Water	Benzol	BuOH	Dioxane
Zinc oxide		Min. sp.	EtOH	Benzol	BuOH Water	Dioxane
Lead-zinc		Min. sp.	EtOH Water	BuOH	Benzol	Dioxane
Titanium–zinc		Min. sp.	EtOH	BuOH	Benzol Water	Dioxane
Weathered Films						
Clear linseed oil	Water	Min. sp.	Benzol	EtOH	BuOH	Dioxane
White lead	Water	Min. sp.	EtOH	Benzol	BuOH	Dioxane
Titanium dioxide	Water	Min. sp.	Benzol	EtOH	BuOH	Dioxane
Zinc Oxide		Min. sp.	EtOH	Benzol Water	BuOH	Dioxane
Lead-zinc		Min. sp. Water	EtOH	Benzol	BuOH	Dioxane
Titanium–zinc		Min. sp.	EtOH Water	BuOH	Benzol	Dioxane
Wood						
Wood		Min. sp.	Benzol	BuOH	Dioxane	EtOH Water

*Abbreviations or symbols: Min. sp., mineral spirits; EtOH, ethyl alcohol; BuOH, butyl alcohol.

creased when the films were dried, except for films soaked in dioxane. Their density was not regained until the redried film had been leached with water and again redried.

Water and mineral spirits leached only moderate quantities of soluble substances from the films, but the other liquids dissolved large quantities, from 36.3 grams per 100 cubic centimeters for benzol to 55.5 grams per 100 cubic centimeters for butyl alcohol. Films that could be measured had swelled in area during soaking, but the ratio of areal to volumetric swelling varied widely (from 0.30 to 0.86). When the films were redried, they shrank to a smaller volume, area, and thickness than they had before soaking. This shrinkage corresponded at least roughly to the loss of soluble matter during soaking.

All of the organic liquids, even mineral spirits, swelled linseed oil films more than water did. Wood, in contrast, is more highly swollen by water than by the organic liquids. That might be expected if linoxyn is a gel of low polarity, wood is highly polar, and similar polarity between gel and liquid determines the swelling capacity of the liquids (2, 3, 4, 5). Such a consideration accounts for the closely related liquids, water, ethyl alcohol, and butyl alcohol, swelling linseed oil films increasingly in the order named and swelling wood in reverse order. But with dissimilar liquids, other factors not yet fully understood became important in the swelling of both wood and linseed oil films. Thus dioxane is less polar but swells wood more than butyl alcohol does, and mineral spirits, which is even less polar than benzol, swelled linseed oil films less than highly polar ethyl alcohol did and far less than benzol did.

The relative positions of the liquids for the swelling of wood and of the oil and paint films tested are indicated in Table 2. Graham (2) found the same order for water, mineral spirits, ethyl alcohol, butyl alcohol, and benzol in the swelling of films of bodied linseed oil.

White Lead Paint: Films of white lead in linseed oil absorbed less liquid and swelled less volumetrically than unpigmented films of linseed oil in all of the swelling liquids. The statement remains true when the absorption and swelling of unpigmented oil films are taken as 70 per cent of the values recorded in Table 1 because the pigmented films contained 70 per cent oil and 30 per cent pigment by volume. In water, white lead was the only pigment tested that effected such reduction. In the other liquids, however, all pigments reduced absorption and swelling to less than 70 per cent of the values for unpigmented linseed oil, and in that respect white lead was no longer more effective than other pigments.

The liquids stood in the same order of increasing absorption and swelling for films of white lead paint as they did for unpigmented films of linseed oil, as can be readily seen in Table 2. Swelling efficiencies were 91 and 95 per cent for ethyl and butyl alcohol, respectively, which indicate the development of slight porosity in the films, and 97 to 100 per cent for other liquids. The density of the films decreased when they swelled but was more than regained when they were redried. The increase in density of the redried films corresponded to a shrinkage in volume and a loss of soluble material during soaking.

Loss of soluble material from white lead paint films during soaking was relatively small, but it was larger than that for unpigmented linseed oil films in water and mineral spirits. In the other liquids, the solubility always exceeded 20 grams per 100 cubic centimeters, but it was much less for films of white lead paint than for films of unpigmented linseed oil.

The relation between swelling in area and swelling in volume was more nearly constant in all liquids for films of white lead paint ($\triangle Q_s/\triangle V_s$ = 0.28 to 0.39) than for films of unpigmented linseed oil. When they were redried, all films of white lead paint shrank to less than their volume before soaking. The shrinkage was approximately in proportion to the loss of soluble substances. There was a similar shrinkage in area when the films were redried except for dioxane, for which the area was greater and the thickness correspondingly less than before soaking.

Titanium Dioxide Paint: In water, films of titanium dioxide paint absorbed more liquid and swelled more volumetrically than films of unpigmented linseed oil or of white lead paint. In the other liquids, however, the absorption and swelling by films of titanium dioxide paint were less than by films of linseed oil, and did not differ greatly from films of white lead paint. A comparison of the liquids for their order of swelling (Table 2) of titanium dioxide paint film and clear linseed oil film shows that for the titanium dioxide paint, water moved from a position below mineral spirits to one above ethyl alcohol and that benzol and butyl alcohol changed places.

The swelling efficiency of water and mineral spirits for titanium dioxide paint film was 100 per cent and that of dioxane was 98 per cent. Ethyl alcohol, butyl alcohol, and benzol, however, had swelling efficiencies of 56, 80, and 87 per cent only, and presumably left the redried films markedly porous. These liquids removed much soluble matter from the films, but apparently did not plasticize the linoxyn sufficiently for the film to contract enough to close the voids when the swelling liquid evaporated. The fact that the redried films gained in density is not inconsistent with this view because the large quantity of soluble matter was much less dense than the pigment, which remained in the films.

In all liquids, films of titanium dioxide paint decreased in density when they swelled, but became denser and smaller in volume when they were redried than they were before they were soaked.

The solubility of films of titanium dioxide paint in each liquid was somewhat higher than that of white lead paint films, and was very nearly equal to 70 per cent of that of films of clear linseed oil (the proportion of linseed oil in the paint), except in water and in mineral spirits. In water and mineral spirits, the solubility of titanium dioxide paint films, like that of white lead paint films, was slightly greater than the solubility of the linseed oil films.

The ratio of swelling in area to swelling in volume for titanium dioxide paint films was 0.36 in water, which is within the range of ratios for white lead paint films, but was much higher, 0.55 to 0.85, in all other liquids in which the measurements could be made. When the films were redried, those that had been soaked in water retained slightly greater in area but were much thinner than they had been before soaking. The films soaked in other liquids shrank in both area and thickness.

Paints Containing Zinc Oxide: In water, films of the three paints that contained zinc oxide absorbed more liquid and swelled more in volume than titanium dioxide paint films. Among the three paints, the film of lead-zinc paint had the lowest absorption and swelling, followed by zinc oxide and then titanium-zinc with the highest. This order agrees with results previously reported.

In liquids other than water, however, the films containing zinc oxide did not differ significantly in absorption and swelling from the films of titanium dioxide or of white lead paints. The absorption and swelling by pigmented films was less than 70 per cent of that by unpigmented linseed oil in all liquids but water, except that films of straight zinc oxide absorbed more dioxane.

Comparison of the liquids for their order of swelling (Table 2) shows that, for zinc oxide and titanium-zinc paint films, water moved from a position below mineral spirits for clear oil and white lead paint films to a position just below dioxane. For the lead-zinc film, water took a position above ethyl alcohol, similar to its position for titanium dioxide film. The changes in the position of water among the swelling liquids suggest that white lead makes paint films less hydrophilic, titanium dioxide makes them more hydrophilic, and zinc oxide makes them still more hydrophilic.

The swelling efficiency of water for films of the three zinc-containing paints was 98 or 99 per cent. Mineral spirits had a swelling efficiency between 95 and 99 per cent for these films, and benzol had an efficiency of 96 or 98 per cent for titanium-zinc and lead-zinc films but only 74 per cent for straight zinc oxide film.

The efficiency of liquids other than water was as low as 59 and no higher than 95 per cent for straight zinc oxide films, and the efficiency of ethyl alcohol, butyl alcohol, and dioxane (after leaching with water) ranged from 69 to 95 per cent for films of lead-zinc and titanium-zinc paint. Thus the organic liquids tend to leave pigmented films porous after soaking and redrying, especially when the films contain zinc oxide. The tendency is less marked for mineral spirits, which also dissolves less, than for the other organic liquids, and for ethyl and butyl alcohols and benzol the tendency extends to zinc-free titanium dioxide paint. The tendency toward porosity is most marked for straight zinc oxide paint and least marked for straight white lead paint.

There is a distinct parallel between the tendency toward porosity and the stiffness and brittleness of the swollen films. Films that become highly flexible and tough when swollen do not become porous when redried, but films that become difficult to bend without breaking and often curl badly when swollen may be highly porous when redried. A conspicuous example was the film of zinc oxide paint in dioxane, which was hard, rigid though badly curled, and very brittle despite a 143 per cent swelling in volume. When it was redried, leached with water, and again redried, it had only 59 per cent swelling efficiency and a decidedly lower density than before soaking. Porosity may be caused by loss of soluble ingredients by the film when the swelling liquid fails to plasticize the film sufficiently (4) to permit it to shrink enough to close the voids.

Films of all three zinc-containing paints decreased in density when swollen in all liquids. When they were redried, they regained or exceeded their initial density, since they lost soluble material of low density, except for zinc oxide paint in benzol and all three paints in dioxane. The exceptions were always films that became porous, as indicated by low swelling efficiency of the swelling liquid.

Films of the three zinc-containing paints that had been soaked in dioxane retained from one-fourth to more than half of the dioxane when they were redried, and the redried volume was from 48 to 158 per cent greater than the volume before soaking. In contrast, the zinc-free films retained less than 6 per cent of the dioxane. The reason for this effect of zinc oxide is not clear, but it may be associated with the stiffness and brittleness of the zinc-containing films swollen in dioxane. A structure of hard, nearly impermeable walls enclosing cavities filled with dioxane may be formed after the soluble substances have been leached out of the films. When the redried films were soaked in water, they quickly became flexible and reasonably tough again, and the dioxane was leached out by the water. After another redrying, the films shrank considerably in volume.

The solubility of the zinc-containing films in water was moderate, but somewhat greater than that of the films with no zinc. In mineral spirits, the solubility was less than that of the white lead and the titanium dioxide films, and less to essentially the same as that of the unpigmented linseed oil film. The other liquids dissolved much more than mineral spirits or water did. Solubility of the zinc-containing films in ethyl alcohol, butyl alcohol, and benzol was always less than 70 per cent of the solubility of unpigmented linseed oil, and was less than the solubility of titanium dioxide film and not very different from the solubility of white lead film.

The solubility of the zinc-containing films in dioxane was overbalanced by retention of dioxane until the dioxane was leached out with water. After the films were leached the quantity dissolved by dioxane and the leach water came to 104.4 grams per 100 cubic centimeters for zinc oxide film, 65.3 grams per 100 cubic centimeters for titanium-zinc film, and 57.7 grams per 100 cubic centimeters for lead-zinc film. Most of this solubility must be attributed to the dioxane.

The solubility in dioxane of the zinc oxide paint film, and probably of the lead-zinc and titanium-zinc films, was so high that some of the dissolved material must have come from the pigment. The soaking liquid was not examined for presence of zinc compounds, but tests were made on the solubility of dry zinc oxide, white lead, and titanium dioxide in both dioxane and butyl alcohol. None of the pigments proved appreciably soluble in the liquids. Presumably, then, dioxane dissolves zinc soaps formed in the paint films by the reaction of the zinc oxide with acid decomposition products of linseed oil.

The ratio of areal to volumetric swelling, $\triangle Q_s$ $\triangle V_s$, for the titanium-zinc films varied from 0.32 to 0.69, much like the variation for titanium dioxide films. The ratio for zinc oxide films ranged from 0.29 to 0.88 in organic liquids, but was 0.24 in water. The ratio for lead-zinc films ranged from 0.20 to 0.38 only, much like the small range for white lead films. When $\triangle Q_s / \triangle V_s$ is large, the swelling in thickness is correspondingly less than would otherwise be expected.

When redried, films of the zinc-containing paints shrank below their volume before soaking, which corresponds to the loss of soluble material during soaking with adjustment for any development of porosity. The films soaked in water remained somewhat swollen in area, but became correspondingly thinner, as did also the

film of lead-zinc paint soaked in dioxane and then leached with water. In the other cases, except when the dioxane was not leached out, the films shrank in area when redried, but usually to less extent than they shrank in thickness.

Results with Weathered Films

Results with films that had been weathered artificially are reported in Table 3.

Linseed Oil without Pigment: Weathered films of unpigmented linseed oil absorbed less water, dioxane, benzol, and mineral spirits, but about the same amount of ethyl alcohol and butyl alcohol, as the unweathered films. The swelling of weathered films was a little less than the absorption. Swelling efficiencies were 87 per cent in water, 92 per cent in ethyl alcohol and mineral spirits, 95 per cent in benzol, and 99 per cent in butyl alcohol and dioxane. Thus the weathered films were more inclined to become slightly porous than the unweathered films, which is further indicated by failure of the weathered films soaked in water and mineral spirits to regain their original density when redried.

The liquids stood in the same order for swelling weathered oil films as for unweathered films (Table 2), except that benzol, which fell between butyl alcohol and dioxane for unweathered films, dropped to a position between mineral spirits and ethyl alcohol. The solubility of the weathered films in water and in mineral spirits was greater than for the unweathered films, but in the other liquids the weathered films were considerably less soluble than the unweathered films. Nevertheless, the weathered films remained much less soluble in water and in mineral spirits than in any of the other liquids.

Weathered films of white lead paint absorbed less and swelled less than the unweathered films in all liquids. Swelling efficiencies for weathered films ranged from 83 to 94 per cent, which indicates the development of porosity. Nevertheless, all white lead films were higher in density after they were redried than before they were soaked because of loss of lightweight soluble matter to the soaking liquid.

The order of the liquids in swelling power (Table 2) was the same for the weathered as for the unweathered white lead films, except that benzol and butyl alcohol exchanged positions. Weathered films were more soluble than the unweathered films in mineral spirits, but were much less soluble than the unweathered films in the other liquids.

The ratio of areal to volumetric swelling was always less for the weathered than for the unweathered films of white lead paint. All weathered films of white lead paint shrank in volume when they were redried.

Titanium Dioxide Paint: Weathering greatly reduced the absorption and swelling of titanium dioxide paint films in water. The weathered film, in fact, swelled slightly less than weathered white lead or linseed oil films. In the other liquids, weathered titanium dioxide films absorbed and swelled less than the corresponding unweathered films, but the reduction was much less marked. Their absorption and swelling were greater than for weathered white lead films in ethyl alcohol, butyl alcohol, and benzol, and somewhat less than for white lead in dioxane and mineral spirits.

The swelling efficiency of the liquids for weathered titanium dioxide films ranged from 82 to 95 per cent except in dioxane, where it was 105 per cent. The high efficiency for dioxane may be erroneous, however, because the titanium dioxide film curled exceptionally badly in dioxane and proved very difficult to handle.

The order of the liquids in swelling power (Table 2) differed for weathered and unweathered titanium dioxide films in that water dropped from a position above ethyl alcohol for the unweathered films to a position below mineral spirits for the weathered film, and benzol changed places with ethyl alcohol. In all of the liquids, the solubility of the titanium dioxide films was less for weathered than for unweathered films.

The ratio of areal to volumetric swelling was less for the weathered than for the unweathered films in ethyl and butyl alcohols, but greater in water, benzol and mineral spirits. All weathered films of titanium dioxide paint shrank in volume when they were redried.

Paints Containing Zinc Oxide: Weathered films of the three paints that contained zinc oxide absorbed and swelled less than the corresponding unweathered films, except that the weathered straight zinc oxide paint absorbed and swelled slightly more in ethyl alcohol than did the unweathered film. The extent to which weathering decreased swelling, however, was usually greater for water than for the other liquids. Nevertheless, the weathered films of zinc-containing paints still swelled much more in water than did weathered films without zinc oxide.

In liquids other than water, the zinc-containing films did not differ greatly in swelling from the films of titanium dioxide or of white lead paint, and their swelling was less than 70 per cent of that of weathered linseed oil except in mineral spirits.

Water took a lower position in the series of liquids for swelling (Table 2) the weathered than the unweathered films of zinc-containing paint, as has already been noted with titanium dioxide paint. Perhaps this indicates that weathering in general diminishes the hydrophilic character of pigmented paint films. The order of liquids other than water was the same for weathered and unweathered films containing zinc oxide, except for a transposition of the neighboring liquids benzol and butyl alcohol for the lead-zinc films. This transposition occurred also for the weathered and unweathered films of white lead paint.

The swelling efficiency of water for the weathered film of zinc oxide paint was 90 per cent, and that for the lead-zinc and titanium-zinc paints was 98 per cent. Other liquids always had a lower swelling efficiency than water for the same zinc-containing paint. The swelling efficiencies for the weathered films closely parallel those for the unweathered films, and reveal a marked tendency for the zinc-containing paints to become porous when redried. Most of the films increased in density when redried because of a substantial loss of soluble ingredients of low density during the soaking. There was a decrease in density or failure to gain in density, however, for the three zinc-containing paints in water and for the zinc oxide and titanium-zinc paints in dioxane.

The weathered films of zinc-containing paints, like the unweathered films, retained dioxane after they were redried until the dioxane was leached out in water and the films were again redried. Such retention by the weathered films was proportionately less than by the unweathered films, although it was still substantial.

The solubility of the weathered films of zinc-containing paints was always less than that of the corresponding unweathered films in the same liquid. The solubility of the weathered films in water was low, from 0.5 to 1.8 grams per 100 cubic centimeters. In dioxane it was from 27.4 to 30.6 grams per 100 cubic centimeters and in the other liquids it was from 2.4 to 11.3 grams per 100 cubic centimeters.

The ratio of areal to volumetric swelling, $\triangle Q_s / \triangle V_s$, for weathered films of zinc-containing paints was always lower in water than in organic liquids, as was the case for unweathered films of all paints and of linseed oil. This was not always the case for weathered films that contained no zinc oxide, however. Weathering sometimes raised and sometimes lowered

the ratio $\Delta Q_s/\Delta V_s$ for corresponding films of the zinc-containing paints without revealing any consistent pattern.

After films of zinc oxide and of titanium-zinc paints were soaked in water and then redried, they were larger in both volume and area than they had been before they were soaked. Films of lead-zinc paint were larger in area and only slightly smaller in volume than they had been before they were soaked.

All zinc-containing films soaked in dioxane were larger in both area and volume after they were redried than before they were soaked, but they shrank when subsequently soaked in water and redried. The films of zinc oxide paint still remained larger in volume and the film of titanium-zinc paint remained larger in both volume and area, however, than they had been before they were first soaked in dioxane. When the final volume of a film was larger than the original volume, the final density was lower than the density at the start of the soaking tests.

Conclusions

Films of linseed oil and of linseed oil paints absorb, swell, and lose soluble ingredients in a number of organic liquids in much the same manner as they do in water. The organic liquids can be arranged in an order of increasing swelling power that is nearly the same for all of the oil and paint films, both before and after the films have been weathered artificially. The order of the organic liquids in this series is mineral spirits, ethyl alcohol, butyl alcohol, benzol, and dioxane, except that for unweathered films the neighbors butyl alcohol and benzol may exchange places, and for weathered films benzol sometimes drops to a position between mineral spirits and ethyl alcohol.

The order of the liquids in the series differs greatly from their order for the swelling of a strongly hydrophilic gel such as wood. Mineral spirits and benzol fail to swell wood measurably, but both swell oil and paint films, with mineral salts at the bottom but benzol next to the top in the series for wood and at the top of the series for oil and paint films. The order of the series of homologous liquids (water, ethyl alcohol, and butyl alcohol) for wood is the reverse of the order for oil and paint films.

Polarity appears to be one of several properties of liquids that govern their swelling power. The more polar liquids swell hydrophilic gels to a greater extent and hydrophobic gels to a lesser extent than the less polar liquids. Thus oil and paint films seem to be less hydrophilic than wood, as might be expected.

But properties other than polarity also affect the swelling power of liquids. For oil and paint films, one of the other properties may be the solvent power of the swelling liquid for ingredients of the films, because the high-swelling organic liquids always

Table 3.—AFTER WEATHERING—ABSORPTION, SWELLING, AND RELATED DATA FOR FREE FILMS OF UNBODIED LINSEED OIL AND LINSEED OIL PAINTS WHEN SOAKED IN DIFFERENT LIQUIDS FOR THREE DAYS AND THEN REDRIED.

Paint	Swelling liquid	Density			Initial thickness	Absorption of liquid	Swelling			Swelling efficiency	Redried			Weight change from initial to redried condition
		Dry	Swollen	Redried	T_o	A/V_o	In volume ΔV_s	In area ΔQ_s	In thickness ΔT_s	$\frac{\Delta V_s V_o}{A}$	Volume ΔV_r	Area ΔQ_r	Thickness ΔT_r	S_2/V_o
					Mils	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Gm. per 100 cc.
Linseed oil	Water	1.18	1.17	1.17	2.5	6.2	5.4	6.4	-1.1	87	-1.9	-2.3	0	-3.4
	Ethyl alcohol	1.15	1.02	1.16	3.8	60.2	57.0	27.5	+10.0	92	-26.0	(1)	.....	-29.6
	Butyl alcohol	1.15	.97	1.15	4.4	96.1	95.0	57.0	+30.5	99	-23.4	-15.8	-8.9	-26.1
	Dioxane	1.17	1.07	1.15	2.8	322	319	(1)	.....	99	-28.3	(1)	.....	-34.6
	Benzol	1.17	1.07	1.17	2.6	56.2	53.4	(1)	.....	95	-19.7	(1)	.....	-22.8
	Mineral spirits	1.18	1.14	1.17	2.9	11.0	10.1	3.1	+6.6	92	-.5	+.3	-.3	-12.4
White lead L	Water	3.02	2.95	3.03	3.1	6.2	5.3	.8	+4.4	85	-1.2	0	-.8	-2.6
	Ethyl alcohol	3.03	2.90	3.26	3.3	20.0	16.5	5.8	+11.2	83	-11.5	-2.6	-9.4	-14.0
	Butyl alcohol	3.06	2.70	3.27	3.1	31.4	28.5	8.5	+19.5	91	-10.5	-2.6	-8.2	-13.3
	Dioxane	3.07	2.04	3.16	2.9	117	110	31.4	+59.0	94	-8.2	+10.6	-17.0	-17.8
	Dioxane, then water	.....	.....	3.25	.....	120	113	33.4	+60.7	94	-11.8	+8.6	-18.8	-21.8
	Benzol	3.06	2.87	3.26	3.0	22.3	18.9	(1)	.....	85	-10.1	(1)	.....	-13.2
	Mineral spirits	3.04	2.90	3.19	3.0	14.8	13.5	1.7	+11.8	91	-6.8	-.1	-6.6	-11.6
Titanium dioxide T	Water	2.28	2.22	2.28	3.0	5.3	4.9	3.7	+1.1	92	-.3	-1.7	+1.6	-.6
	Ethyl alcohol	2.26	2.05	2.35	3.1	29.7	24.6	19.0	+5.4	83	-9.1	-6.3	-2.8	-13.2
	Butyl alcohol	2.28	1.91	2.34	2.9	43.6	39.3	22.6	+14.7	90	-8.4	-6.3	-2.3	-13.2
	Dioxane	2.26	1.73	2.36	3.2	71.5	74.7	(1)	.....	104	-10.0	(1)	.....	-14.0
	Dioxane, then water	.....	.....	2.39	.....	71.9	75.8	(1)	.....	105	-11.1	(1)	.....	-14.1
	Benzol	2.24	2.08	2.30	3.3	23.8	19.5	18.6	+1.2	82	-7.3	-5.9	-1.8	-11.2
	Mineral spirits	2.25	2.16	2.28	3.4	9.7	9.2	5.4	+3.6	95	-2.3	-3.0	+.7	-2.4
Zinc oxide Z	Water	2.60	2.34	2.57	3.0	33.1	29.7	8.2	+20.0	90	+.3	+1.2	-.8	-1.8
	Ethyl alcohol	2.59	2.35	2.69	3.2	26.2	22.4	11.6	+10.0	86	+6.5	-5.0	-1.2	-7.6
	Butyl alcohol	2.60	2.24	2.68	3.2	35.8	31.1	14.4	+15.7	87	-6.7	-5.4	-1.2	-9.5
	Dioxane	2.61	1.85	1.80	2.9	116	107	38.7	+49.0	92	+48.2	+3.2	+43.6	+5.5
	Dioxane, then water	.....	.....	1.71	.....	141	107	38.7	+49.0	76	+34.5	-3.0	+38.7	-30.6
	Benzol	2.65	2.36	2.69	2.4	27.3	23.7	14.2	+8.9	87	-3.1	-3.2	+.2	-4.5
	Mineral spirits	2.60	2.42	2.62	3.1	15.3	12.7	3.9	+8.6	83	-1.2	-1.1	+.1	-1.4
Lead-zinc L_{35}	Water	2.87	2.60	2.86	3.5	17.3	16.9	2.5	+14.0	98	-.3	+1.2	-1.3	-1.3
	Ethyl alcohol	2.88	2.65	3.01	3.5	19.9	18.6	7.2	+11.4	93	-7.3	-3.2	-4.0	-8.5
	Butyl alcohol	2.88	2.50	3.01	3.5	30.4	28.7	9.7	+18.4	94	-7.4	-3.4	-3.9	-9.3
	Dioxane	2.89	2.08	2.79	3.3	89.0	79.5	28.0	+39.1	89	+.4	+1.8	-1.4	-8.4
	Dioxane, then water	.....	.....	2.98	.....	107	91.8	29.9	+50.0	86	-12.2	-0.1	-12.3	-27.4
	Benzol	2.88	2.51	2.98	3.4	29.0	27.6	15.0	+11.5	95	-5.3	-1.1	-4.0	-5.8
	Mineral spirits	2.88	2.70	2.94	3.4	13.6	12.1	2.9	+9.8	89	-3.3	-.7	-1.0	-3.6
Titanium-zinc T2	Water	2.24	1.97	2.24	3.6	28.3	27.7	12.3	+14.3	98	+.1	+0.7	-2.6	-.5
	Ethyl alcohol	2.27	2.09	2.39	2.9	23.9	22.0	16.9	+5.0	92	-9.2	-8.5	-.7	-10.7
	Butyl alcohol	2.26	1.94	2.37	3.7	37.5	35.6	22.5	+15.0	95	-9.4	-8.5	-.9	-11.3
	Dioxane	2.26	1.69	2.07	3.6	103	95.5	60.1	+22.2	93	+7.7	+2.0	+5.9	-3.2
	Dioxane, then water	.....	.....	2.21	.....	129	106	(1)	.....	82	-11.0	(1)	.....	-29.8
	Benzol	2.26	1.90	2.32	3.5	40.5	39.3	31.3	+6.4	97	-4.1	-3.4	-.8	-4.2
	Mineral spirits	2.28	2.10	2.30	2.9	16.3	15.6	7.9	+7.3	96	-2.0	-3.0	+1.1	-2.4

1 Film too fragile to measure.

dissolved relatively large quantities of soluble constituents from the films.

The position of water in the series of swelling liquids varies greatly with the composition of the film. For films of unpigmented linseed oil and of white lead paint, water has less swelling power than mineral spirits, but for unweathered films of zinc oxide and of titanium-zinc paint, water has a very high swelling power, and is exceeded only by dioxane. Water stands about in the middle of the series for unweathered films of titanium dioxide and of lead-zinc paints.

The marked shifting of the position of water suggests that its position is determined chiefly by the hydrophobic character of the film, and that titanium dioxide makes paint films less hydrophobic, zinc oxide makes them still less so, but white lead makes them more hydrophobic. If so, weathering partly offsets the effects of titanium dioxide and zinc oxide, because the position of water drops one or two places in the series after the titanium dioxide paint and the zinc-containing paints are weathered.

Organic liquids have less than 100 per cent swelling efficiency for oil and paint films more often than water does. This may be due largely to the greater quantity of soluble material leached from the films by most of the organic liquids. Low swelling efficiency probably results from voids left by dissolved material when the film fails to shrink sufficiently in volume as the swelling liquid evaporates. If so, a second factor in the development of porosity in films may be the plasticity of the remaining insoluble portion of the film, particularly the plasticity when the last portions of swelling liquid are evaporating. Voids may be readily closed in a highly plastic film, but remain in a more rigid film.

Consistent with this view are the facts that unpigmented films seldom become seriously porous, and weathering, which makes films harder and more brittle, also increases the tendency for the films to become porous when soaked and redried. It may then be concluded that the organic liquids do not plasticize the structural framework of paint films so well as water does.

Dioxane exhibits peculiar behavior toward zinc-containing films that may be related to the plasticity of the insoluble framework of the films. Zinc-containing films swollen in dioxane become stiff and brittle and when redried retain much of the dioxane for a long time.

Wood presents a parallel in that, when impregnated with organic liquids of high volatility but little or no swelling power, the liquids dry out much less rapidly than do less volatile liquids that swell wood appreciably. The nonswelling liquids do not penetrate the walls of the wood cells, and therefore must dry by the slow process of evaporation in place and escape of the vapor through the tortuous channels connecting the cavities. Dioxane, then, may be quite unable to penetrate and plasticize the insoluble framework of zinc-containing paint films left after the soluble components have been leached out, and thus remains trapped in the voids formed by loss of the soluble components.

The solubility of oil or paint films in mineral spirits is low, seldom much greater than their solubility in water. Their solubility in the other organic liquids, however, is high, more than 20 grams per 100 cubic centimeters for unweathered films, except those of zinc-containing paints in benzol, where it is about 15 grams per 100 cubic centimeters. Clear oil films are more soluble than pigmented films in the organic liquids other than mineral spirits, except that zinc-containing films are more soluble than clear oil films in dioxane.

Weathered films, which have already lost much soluble matter during the weathering, are less soluble in organic liquids other than mineral spirits than the corresponding unweathered films, but even the weathered films have moderate to high solubility.

The distribution of volumetric swelling between area and thickness of films varies widely in the organic liquids, just as it does in water. For unweathered films and for weathered films of zinc-containing paints, the ratio of areal to volumetric swelling, $\triangle Q_s/\triangle V_s$, seems always to be larger in organic liquids than it is for films of the same kind in water. The rule is generally true, but there are some exceptions for weathered films of white lead and of titanium dioxide paints. The difference in action between water and organic liquids may be related to the varying position of water when the liquids are arranged in order of swelling power, and to the greater tendency for films swollen in organic liquids to become porous when redried than is the case when they are swollen in water and then redried.

The volume, area, and thickness of films of linseed oil or paint are usually reduced when the films are swollen in organic liquids and then redried, as was found with water. The reduction is roughly proportional to the loss of soluble material to the soaking liquid. The shrinkage, however, is reduced in proportion to any porosity developed in the redried film, and, if the film becomes porous enough in relation to the solubility, its volume may actually be increased. When the films are redried, much the same irregularities in distribution of the volumetric shrinkage between area and thickness occur as are observed during swelling.

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The Past, Present, and Future of Wood Utilization[1]

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One firm's experiences in realizing 100 per cent utilization of logs are described. Wood residues formerly a liability are now converted to wood flour, pulp chips, and fuel. Prediction is made that home building will be key area of development of products from wood wastes in the future.

WITHIN A FEW MILES of our plant are great mountains of sawdust rotting away—an eyesore and a puzzle to many people not familiar with the production of lumber.

We pioneered the use of Eastern white pine in the manufacture of wedgie heels. From the start, the disposal of blockings, edgings, sawdust, and shavings was an important factor.

At first, local farmers were happy to haul away the kiln-dried sawdust and shavings for bedding, but we had to dispose of the blockings and edgings ourselves. Then when the local farmers and poultry raisers were busy, we had to pay to have this waste hauled away and had to provide a dumping ground, at considerable expense, for the plant was located in the heart of the village.

Consequently, it was a natural to get into the manufacture of wood flour. If anyone has had the experience of being lost in the woods and had to chart his way out without any experience, he will recognize the condition we found ourselves in when we entered the wood flour field. There was limited information available, there were no standards as to the material content from an analytical standpoint, and as to mesh size—it was nothing but a jungle. There was no handbook for the actual milling, sifting, and packaging of this material in an efficient and safe manner.

However, as wood flour millers, we adopted the machinery and equipment being used by the flour milling industry in general. We subsequently developed a fairly efficient and somewhat profitable operation by converting our own waste, plus the waste of surrounding planing mills which were using air- or kiln-dried material.

Then came the "feast and famine" era with such a great demand for wood flour that many people got into it, and some of the large chemical firms, not sure of their source of supply, began producing their own wood flour. This condition soon created the problem of disposal of production for the average, independent wood flour miller.

Some seasons, due to unusual weather conditions, the plant often ran short of raw material. Therefore, it was decided to start a policy of installing, lending, or selling a variety of hogs to different planing mills so that their ground-up wood could be added to the sawdust and shavings to increase the yield of wood waste residue. At the same time, a battery of large silos was built to store semi-finished raw material. Here the history of "feast or famine" repeated itself, for many times our railroad siding and the sidings at surrounding railroad stations would be jammed with freight cars we could not unload. At other times, the silos would be bone dry.

Necessity being the mother of invention, we became interested in creating additional wood waste for our own use. We therefore became involved in a log debarking operation and are using the slabs and edgings from this operation for the creating of chips for the paper mills, while the bark-free sawdust and smaller chips, in sizes too small for the paper mills, are converted into wood flour or fuel.

A bark separation installation has been developed for kiln-dried, white pine edgings wherein the white wood ends up as raw material for the wood flour mill, and the bark ends up in 16-mesh or finer fuel. One pound of bark or ground wood 20-mesh or finer, burned in suspension in the average boiler plant, under slight air pressure, will favorably compete with a pound of Bunker C oil or coal as far as the production of B.T.U.'s is concerned.

Over a period of years, this firm has been using round-edge, white pine lumber. Northeastern, square-edge, white pine, kiln-dried, weighs one ton per thousand board feet. After getting wedgie heels out of the lumber, we are still able to ship over one ton of finished wood flour for every thousand board feet of lumber we actually use. That, we call utilization of the dry wood.

From the same logs we get wet weight of about two tons of additional residue from the sawmill for every thousand board feet of lumber produced, which is converted into chips for the pulp mill, additional raw material for the wood flour mills, and bark for the boilers. That, we consider utilization of wet, or green, wood. But that does not take care of the waste in the logging operation, and there is plenty of room for utilization in the woods.

Due to usual small sawmill operations in Maine, we have extended quite far in our own locality and have had fairly good luck in having a few of our neighbors install debarkers, using our premises as a concentration yard for chipping. We ship many thousands of tons of wood flour and chips out of what was originally not only total waste but also a liability, as it cost money to have it removed.

The lumber and paper producers, the large industrial users of lumber, and timberland owners should get together often and, without any reservations, work together as groups in each and every locality toward getting the most out of the wood produced in their vicinity.

Now for the future, refer to the sawdust and slab piles mentioned at the beginning. The only way to utilize these piles of unusable waste is to prevent new ones from being created. *I consider this mining white gold out of rotting wood.*

Many plants are using wood in the form of lumber, pulp, plastics, linoleum, and so on, and what is being done would have been considered a miracle 25 years ago. Today, many intelligent and up-to-date businessmen of the forest products industries are creating, from waste from their own plants and their neighbors, hard and softwood laminated doors, and other building items. The exchanging of ideas, such as through FPRS, I am sure has had a lot to do with it.

It seems that, to be a little bit visionary, one of the key areas of development for these waste products in the future will be in the area of home building. We are building homes today essentially as we were

[1] Presented at meeting of FPRS Northeast Section, Oct. 20–21, 1955, in New York City.

The author: J. R. Wilner was the originator of the present system of manufacturing wood wedgie heels and his firm is now the largest manufacturer of these products.

100 years ago, by hand and with great cost.

Now, to look ahead, the next 25 years will see parts of homes, floors, walls, roofs, ceilings—built out of waste wood, in conjunction with binders produced by the chemical industry out of this wood. Many small logs, branches, and small pulp trees will never leave the woods as such, but will be ground up right there to supply the demands of industry. This development will not only include the walls, floors, ceilings, and roofs, but will include the casings and parts for many of the electrical appliances, cabinets, furniture, etc.

The interior finish made from this type of raw material will be far ahead of anything known in homes in the past. It will be cheaper, it will wear better, it will be fire resistant, it will conserve heat, it will give better protection from the weather in both summer and winter, it will give a better appearance. And it will be done by using the products of the forest, as a major item, after grinding up whole trees.

It is believed that these homes will be ordered from a catalog and will be put together as children build things out of blocks at present. These houses will not look like or have the drawback of the present prefabricated houses.

Wood utilization will have a lot to do with changing the concept of housing as we know it at present, just as the automobile industry has changed its product from what we knew at the beginning of the twentieth century. This is a natural development and, once it begins, there is no telling where it will lead.

The forest products industries are on the threshold of a great big future brought about through many changes in their thinking. This will include timber processing from the time the logging crew goes into the woods.

With the great strides chemistry has taken in the last decade or two, the use of electronics and the modern conveyances, such as material handling lifts and loaders, wood utilization can and will enrich not only the lives of the people who make a living from this industry, but a better way of life for all of us.

To paraphrase a well known chemical company's motto, I think the forest products industries have taken great steps in the last few years and can truthfully look to the future and say, "A Better Way of Life Through Wood Utilization."

Research and Wood Use[1]

RICHARD N. JORGENSEN

Assistant Professor of Wood Technology, School of Forestry, Pennsylvania State University, University Park, Pa.

Survey of uses reveals that relatively few new wood products have been developed through research. Major advances have been made in production methods and improved product forms. Aggressive technical research is essential to develop more and better wood products which will help retain present markets and gain new ones. The role of FPRS in helping further research in relation to wood use is pointed out.

ANY DISCUSSION of new wood uses and their relationships to research must have as its basis a survey of the present uses of wood and the numerous research projects which may or may not be responsible for such uses. The results of such a survey show primarily that there are few wood products that are really new. Wood waste fertilizers and animal feeds, fiber and chipboards of all types, modified woods, and pressed waste fuels are truly new products, but houses, furniture, vehicle bodies, flooring, and many others of a long list have been produced from wood for centuries.

The corollary examination of research projects reveals similar results. One commercial laboratory has developed better auto bodies, a new use for two-species laminates, and is testing effects of treating and preserving. University laboratories are studying the anatomy and mechanical properties of untested species, new wood adhesives, the design of test specimens for determining mechanical properties, the action of dowel joints, the engineering of two-species laminates, the strength of nailed truss construction, nondestructive testing methods, and others. Industrial laboratories are studying the toughness of treated woods, new finishes, and better assembly forms. Actual new uses of wood do not figure prominently in this list.

It is apparent, therefore, that the tremendous advances which have been made in the wood-using industries in the past few decades have been primarily in methods of production and forms of products produced. Production has progressed from hand hewn homes to prefabricated houses complete with truss roof; from the hand tool furniture craftsman to the train-carload-a-day furniture factory; from production for a few thousand to production for today's millions. Product improvements have kept most wood products competitive in style, durability and usefulness. To accomplish such extreme changes in production volume and in forms of products so that wood could hold its place in contending markets has meant learning more about wood, more about handling wood, and more about putting wood together—all learned through research of one type or another.

But it is not sufficient that wood research be used only to defend the simple, established uses and the resultant markets. New materials, and other materials, constantly dispute wood products on the market and published figures show many of them are based on extensive research programs much larger than that of the wood industries. The wood-using industries must develop an aggressive, technical research program, sufficiently diversified to produce a score of better and more satisfying uses of wood for each one lost to the competition. In many cases disputed markets can be saved by early research properly coordinated with development and promotion. Continued emphasis on the fact that the wood industry of today

[1] Presented at meeting of FPRS Northeast Section Nov. 4–5, 1954, in New York City.

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is the result of research will bring realization that the wood industry of tomorrow cannot materialize unless based on a broad research program.

The need for such a broad, technical research program may also be aptly emphasized by pointing out some of the many things which are still unknown today in spite of much past work. The chemistry of wood is as yet not exactly known, and more important, methods of removal of important materials from the wood are still unsolved. In our present chemical age, many of these may lead to new uses of large volumes of wood material.

The engineering of wood is only about 40 years old and already has gone far. Many markets once thought lost to wood have been regained and should be held.

Second growth timber characteristics, the use of lower grade material, the combinations of species through new adhesives, and new demands in types of public construction daily present new research problems. The possibilities of faster grown, better timber through genetic development will create problems from standing tree to crated product. There is no end to what we may learn about wood.

The U. S. Forest Products Laboratory has estimated that there are as many as 50,000 producers of wood products in the country which fall for the most part in the size class unable to support research in their particular operation. These industries must support some planned program of research in wood, must purchase the answers to their specific problems, or be in the unenviable position of going without the benefits of any new developments until they appear on the open market. Technical information is available in many publications, provided the industry is familiar with the numerous sources of such material and is able to screen all of it to draw forth applicable information. Many plants provide no personnel for the study and application of such technical information.

Because it represents all aspects of the wood using industries, the FOREST PRODUCTS JOURNAL has developed as one of the outstanding publications bringing to industry and researchers the results of work in all fields of wood use and manufacturing. Readers find it a quick and certain method of reviewing the most outstanding research findings or discussions of production problems which may apply to their particular field. At the last four meetings of the Northeast Section of FPRS, a further effort has been made to bring together those interested in fundamental and applied research through the establishment of research discussion groups. Here, in addition to the papers of the regular technical sessions, researchers and other interested persons can discuss current problems, obtain and give advice, and stimulate new research where needed.

Through publications, meetings, and discussions, FPRS has gone a long way toward furthering research in relation to wood use and has done much toward filling a gap where much work is still to be done.

Laminates in Building--1975[1]

ROBERT I. SOLOW

General Manager, Allegheny Lumber Co., Elkins, W. Va.

A completely new building industry by 1975 is foreseen, with sandwich panels providing the key to "package homes" of superior design and quality. These panels are complete building modules capable of carrying large loads and spanning great distances without intermediate supports. Coordinated industry effort is needed now to develop more universal acceptance of sandwich panels and promote their use through a package system.

I PREDICT A MERGER between laminates and prefabrication by 1975, a move destined to establish a completely new building industry. I foresee "package homes" unexcelled in design and quality and within the price range of the vast middle income group.

Let us review the industry and rationalize these beliefs. Plywood 20 years ago was a relatively small industry accepted by many with some degree of skepticism. With the advent of technically improved resin glues and with the cooperation of manufacturers through an association, the once-infant industry has virtually become a giant with every indication of greatly increased growth for many years to come.

At this point we have established more than just a product to insure the future utilization of wood but have actually created a laminating industry, a production of great diversification manufacturing varied materials for literally thousands of uses. The laminator has at his disposal a vast number of metals, plastics, paper products, wood, fiberboard, asbestos, and composition materials. But more important, he has the means to laminate those materials in various combinations, each designed to possess a given set of properties and to perform a specific function. These laminates are commonly called "sandwich panels", produced by the bonding together of dissimilar materials.

To better understand the place of sandwich panels in the building industry, first consider present-day construction. It is obvious that the existing method of constructing a custom-built home by cutting one board and pounding one nail at a time does not offer the most efficient means of construction. It is true that we have entered upon a form of prefabrication where the efficiencies of greater purchasing power, fabrication on a production basis, and sub-assembled components have combined to offer a noticeable efficiency in home building. However, this in itself is not sufficient to protect the wood industry from the inroads of competitive materials whose every effort is bent in taking over some phase of this market.

Laminates can help in two major degrees. Initially they lend themselves to the creation of a complete building module — structurally independent, fully insulated, factory prefinished, and ready for rapid installation. Secondly, the sandwich panel, by virtue of its I–beam like construction, is capable of carrying large loads and spanning greater distances without intermediate supports.

Assuming we begin with a finished basement or foundation, we initially eliminate the studs on 16-inch centers in favor of columns on 8- or 12-foot

[1] Presented at meeting of FPRS Northeast Section, Oct. 20–21, 1955, in New York City.

The Author: R. I. Solow holds degrees from N. C. State College and Yale U., is now general manager of the Allegheny Lumber Co. (plywood division). He was formerly sales manager of the plywood department of Keller Products, Manchester, N. H., where he had also served as production foreman as well as in the quality control and time study departments.

centers. The same will apply to the roof and floor. The next step is to eliminate all internal load bearing members. In addition, we no longer plan on sheathing, siding, insulation lath, and plaster. All of this is contained in a single panel efficiently combined under accurately controlled factory conditions.

The panel design at the factory begins with the inner core, which must add rigidity to the panel and be a good insulator. These requirements are descriptive of wood itself and balsa is often selected for its light weight and high insulating values. The U factor of a 2-inch core is often superior to four or five times its thickness in masonry construction. Of course, there are other types of core constructions, such as plastic impregnated paper honeycomb whose cells are filled with mineral base materials for improved insulation, and lumber egg-crate construction whose grids may be filled with flexible insulation such as fiberglass.

Any of these cores may be faced with a variety of panels consistent with its actual use as exterior or interior wall, roof, or floor panels, provided that the facing materials on a single panel are identical or similar so that the laminate is properly balanced. For example, the outside wall might be faced with fir plywood, porcelain, a well protected fiberboard, or reinforced plastic. The interior partition panels might be faced with fine hardwoods, decorative plastics, or inexpensive composition materials. The inner surface of the roof panel becomes the finished ceiling while that of the floor panel could be the subflooring or finished floor. Since the room partitions are non-load bearing, floor plans are flexible and may be re-arranged with changing family needs.

Production-wise, we have excellent means of producing such panels. Many manufacturers have large flat presses capable of obtaining a rapid curing cycle either by strip heaters or electronic heating. However, with the new contact type resins and roller press equipment, panels are produced at the rate of 10–60 lineal feet per minute in virtually unlimited lengths. At present 20-foot panels are regularly manufactured.

There are several means of installing panels and this is one particular phase of construction requiring additional research. However, even present methods utilizing metal fasteners with neoprene gasketing assure an efficient weather-tight joint.

If all of these materials and processes are immediately available, it would seem strange that we have not developed a more extensive usage. I have found both the architect and industrial designer to be receptive to this type of construction and at present we have many instances where paneling, both interior and exterior is being used in sections of buildings essentially constructed by present day methods. In other words, the acceptance is by degree. The individual laminator lacks the coordinated laboratory facilities, architectural staff, and sales promotion to combine the individual panels into a composite package. A task of this proportion requires a coordinated industrial effort to offer a more complete service and to develop more universal acceptance.

It would not be wise to consume the next two decades in accomplishing this task. Manufacturers of other materials have made equally impressive strides. Among these are building modules of a complete plastic construction, and others almost entirely of metal. Beyond any doubt, with our countless years of precedence in wooden dwellings we possess a tremendous advantage worth capitalizing on.

Discussion

W. B. Wilkins (Consulting Engineer): Can you give any immediate examples of where the modular structure is being used?

Mr. Solow: I think one of the most interesting installations we recently had was on Mt. Washington, N. H., which has the dubious honor of having about 10½ months of winter throughout the year. A transmitter building was needed on the top of Mt. Washington for one of the new television stations out of Portland, Maine. It would be difficult to construct a building by conventional methods during the short time allowed and under those stringent conditions. However, we did engineer and prefabricate a building within our own shop. Under those conditions, it was easy to trek them to the top of the mountain, install them in a relatively short amount of time, and have a building that would withstand the tremendous wind and snow loads encountered.

P. H. McCormack (National Adhesives): In the construction of these modular panels, have you made any progress in the masking of the joints between the panels? That seems to have been an important problem to many in the panel fabricating field.

Mr. Solow: It still is a big problem. However, we just erected an office building of our own and used aluminum extrusions with neoprene gaskets which go together quickly and are weather tight.

Mr. McCormack: There are a number of people who are not only interested in, but many are already producing sandwich panels for construction, usually limited so far to smaller construction. Contrary to your comment, there seems to be a reluctance on the part of architects to accept that type of construction. They are interested in it, but as far as getting it into the building and selling it to the banks so that they can get the money to build it, that's another problem.

Mr. Solow: What you say is true; however, I think you will find that the architect, as an individual, would like very much to use it. The architect, of course, like anybody else, sells ideas so that anything that is actually new is of tremendous value to him. Again you come back to the word "prefabrication", so the architect has a real job selling it to the bank and selling it to the consumer. In other words, he has to call it by another name. Actually, as a laminator, you can't throw the entire load on one architect. The burden is just too heavy for him. However, as I said, we need a more coordinated attempt to actually work with several architects and several laminators, as well as people who can actually influence building codes to take advantage of what we now have.

R. Mark (Balsa Ecuador Lumber Co.): What is the longest load-bearing free span you know of that is spanned by a sandwich panel.

Mr. Solow: We have had spans up to about 16 feet. Of course, if you let your imagination run wild, you can engineer a panel that will stand almost any distance, providing you have the fit between two skins of the panel.

Mr. McCormack: Along those lines, the U.S. Forest Products Laboratory has 24-foot unsupported sandwich panel with paper core. I'm not sure whether it is load bearing or not, but it is bearing considerable load due to its own construction.

Mr. Solow: Many of the laminators have produced a wood panel which can carry the traditional load of about 50 pounds per square foot.

Mr. Mark: On the Mt. Washington panel you had the snow load. Did you ever calculate the amount of dead snow load you have at any one time?

Mr. Solow: Yes, that was engineered into the building. As a matter of fact, there is more to it than that of a dead load. There was an impact load to contend with, too, with the tower nearby. Ice could accumulate and drop by its own weight on the building. As a result there was a special type of roof panel developed, having a core of end grain balsa to take that impact load. We estimated that the impact load could become as great as 10,000 foot pounds—that is the weight of a 200-pound cake of ice falling a distance of 50 feet.

Around the World in Forest Products Research and Development

Status of Wood Saccharification

Rome, Italy

• A summary statement on the status of wood saccharification, prepared by J. A. Hall, Director, J. F. Saeman, Chemist, and J. F. Harris, Chemical Engineer, U. S. Forest Products Laboratory, Madison, Wisconsin, appears in UNASYLVA, V. 10, No. 1. The article was prepared at the request of FAO in connection with the work of The Technical Panel on Wood Chemistry.

J. A. HALL

Despite early hopes and a large amount of research, wood saccharification has not lived up to expectations, yet today hope seems to burn as brightly as ever. W. W. Moyer, Chem. Tech. 1942, predicted:

"The hydrolysis of cellulose to glucose and simple oligosaccharides will become a dominant economic factor . . . Cellulosic byproducts will find increased utilization as raw materials for the production of simple aliphatic chemicals through chemical engineering and biological processes . . . . Looking far into the future we can see that cellulose, the most abundant of all photosynthetic products, will become one of man's most useful raw materials. The supply is replenished by growth while materials stored from past ages are continuously depleted."

In their summary, the authors point out that wood saccharification is seen to have many facets with many possible combinations of process and product. No comparison of processes is possible without specifying the place where a plant is to be located and the purpose it is to serve.

Thus in some locations the production of refined glucose from wood might be an attractive proposition. In the United States, such a process would merely reduce the consumption of corn, a commodity already in surplus supply and selling at a price controlled by the Government. Similarly, chemicals from cellulosic residues might find a ready market in the United States but in underdeveloped areas they would have no value.

As another example of the hazards of generalizing about saccharification processes, the cost of the acid in the strong sulphuric acid method of saccharification appears prohibitive, but when the acid serves the double purpose of saccharification and the production of ammonium sulphate or ammonium phosphate fertilizer, the process deserves more attention.

In directing a research program on the saccharification and chemical utilization of wood residues, the following points are worthy of special consideration:

Present evidence indicates that no truly simple saccharification process can be anticipated in the foreseeable future. Any efficient plant must be large, relatively complicated, and will require a high level of technical skill in its management and operation. In these respects, wood saccharification plants will be similar to modern well-operated chemical plants.

All evidence suggests that wood hydrolysis processes cannot become important until fuller utilization of the incoming raw material is realized. No single product is sufficiently valuable to pay the cost of raw material collection, handling, and processing.

The immediate outlook for wood saccharification is not highly encouraging. Available processes are suited mainly to special situations. Processes of greater general utility should be developed. Extensive and well co-ordinated research is required to accomplish this end.

Oslo, Norway

• The 1955 Annual Report of the Norwegian Institute of Wood Working and Wood Technology has been issued.

Among the investigations made during 1955 were:

Sawmilling and Planing—A comprehensive volume of data has been gathered concerning sawing and resawing procedures. Among the factors which might affect sawing precision, special attention has been given to the value of spring-set vs. swaged-set teeth, various types of machinery, rotation rate, and handfeeding vs. automatic feeding in cutting operations. An investigation has also been made concerning the sawing precision obtained when using band saws with swaged-set and spring-set teeth as compared with circular saws.

A study has been made regarding the sawing precision obtained with gang saws as related to the lumber dimension, setting-up, hang, and speed of feed.

A German invention of a so-called elastic wedge for gang saws providing individually controlled tightening of the blades has been tested and the results published.

Drying and Moisture Conditions—The experimental kiln drier of the Institute has been in constant operation, to some degree for special purposes. Besides investigations regarding various kiln drying schedules for Norwegian tree species, experiments have been conducted on drying at high temperatures and at different rates of air circulation.

Experiments have been continued regarding the weighing of whole stacks of planks by means of electronic weighing units. By using a recording apparatus, the variations in weight have been registered day and night. In 1953 an investigation was undertaken at about 30 sawmills concerning the moisture content in planed lumber. The investigations were repeated in 1955.

Utilization of Waste—The Institute has carried out extensive experiments concerning solid wood content of peeled and stacked slabs and edgings. It is borne out by results that the solid wood content varies somewhat with the various types of slabs. In most cases it is between 50 and 65 per cent.

Drying of Sawdust—To be suitable for various uses, sawdust must be dry. Drying measurements have been obtained from three different methods employing steam-heated drum kiln, flue-gas-heated drum kiln, and flash drier. The flash drier built on the principle of blowing the sawdust with warm air or flue gas through a pipe system is the cheapest method both as regards equipment and operation.

The Institute is building a drying plant on industrial scale based on the principle of the flash drier. A briquetting press is also being installed.

Glued Lamination and Preservation of Wood Constructions—Representatives from the Institute have made study trips abroad in order to become familiar with the practical experiences gained in industry in this field. A program has now been formulated for the purpose of studying the glued lamination of preserved units.

Abstracts From Current World Literature

Wood Preservation

Barlund, U. Laboratory experiments on competition between rot fungi. *Karstenia,* Helsinki No. 1, 1950 (60–72). 11 refs. [Sw.e.]

Nine wood-rotting fungi were used in the test. Results showing the ability of a second fungus to compete with one established on a block of wood for 1½–2 months are tabulated. Tables and illustrations have English legends. [For. Abs. V. 16, No. 4]

Wood Tanks

Colyer, W. T. Wooden vats for corrosive liquids. *Corrosion Technology, London* 1 (10), 1954 (379–81).

Describes the properties and applications of wood as a material for vat construction. The following species are particularly suitable: Pitchpine, Burma Teak, Peroba de Campos, Siberian Larch, Siberian Redwood, English Oak, Douglas Fir. Air drying is imperative because of the thickness involved. [For. Abs. V. 16, No. 4]

Finishing

Orth, R. Bleaching of wood. *German Patent (East Germany)* No. 1953, Nov. 22, 1952. [G.] From *abstr. in Chem. Zbl.* 125 (24), 1954 (5425). [G.]

Blue-stained wood is first treated with an aqueous solution of KOH or NaOH, causing the micellar structure of the plant and fungal membranes to swell, and then the alkali-impregnated fungal hyphae are treated with a H_2O_2 solution. [For. Abs. V. 16, No. 4]

Wood Properties

Jutte, S. M., and Isings, J. The determination of tension wood in ash with the aid of the phase-contrast microscope. *Experientia* 11, no. 10: 386–7 (Oct., 1955). [In English; German summary]

The authors found that the three commonly used staining reactions for detecting the presence of tension wood in hardwoods (chlorine-zinc-iodine; phloroglucinol-hydrochloric acid; and Safranin fast green) are not applicable to tension wood occurring in ash. However, with the aid of the phase-contrast microscope, the authors were able to make a ring visible in the tension-wood fiber of ash trees; it even became possible to determine the refractive index of the ring material. [Bul. Pap. Chem. V. 26, No. 4]

J. D. Brazier. Bubinga and allied timbers. African species of *Guibourtia* and *Copaifera. Timber Technology,* Vol. 63, No. 2191, May 1955, pp. 237–9.

Species of *Guibourtia* are widely distributed in Africa and produce a number of highly interesting and decorative timbers. In appearance bubinga *(Guibourtia spp)* bears a superficial resemblance to some types of rosewood, It is about the same weight, 50–60 lbs. per cu. ft. seasoned, as Indian or Brazilian rosewood, but its texture is finer. The grain is usually straight or interlocked, but in some logs it is very irregular and wild and these give highly figured veneers when rotary cut. In some quarters there is a tendency to use the name kévazingo for the highly-figured timber. The timber is reported to saw without difficulty and takes a fine finish. It has been used in this country for decorative panelling and offers possibilities for high class furniture. [F. D. C. Tech. Bul. V. 5, No. 28]

Wood Structure

Bosshard, H. H. Structure of a classic raw material. *Sci. Monthly* 81, no. 5: 224–33 (Nov., 1955).

The author discusses some aspects of wood structure, including the formation of woody tissue in the stem and the anatomy of soft- and hardwoods, with particular reference to white pine as an example of the former and birch and ash as representatives of the latter. [Bul. Pap. Chem. V. 26, No. 4]

Humidity Control

Anderson, R. M. This is the season for humidity control. *Paper, Film and Foil Converter* 29, no. 10: 22–5 (Oct., 1955).

The necessity for humidity control particularly during the cooler seasons when extremely dry conditions prevail in many plants is emphasized. Various methods for adding moisture to the air, the cost of the equipment, and results of humidification are discussed. [Bul. Pap. Chem. V. 26, No. 4]

Fire Retardants

Kenaga, D. L. and Erbel, A. J. Flameproofing of cellulosic materials. U. S. Patent 2,725,311, Nov. 29, 1955.

Cellulosic material is made fire resistant by impregnating it with a solution in a volatile solvent of 5–40% of a bis (*w*-monohaloalkyl) *w*-monohaloalkanephosphonate in which the alkyl and alkane groups are alike and contain 2–3 C atoms each and in which the halogens are either Cl. or Br. Thus, ponderosa pine sapwood was treated with a 25% solution of bis (2-bromoethyl) 2-bromoethanephosphonate (I) in aromatic mineral spirits in a modified full-cell process which used atm. pressure. The impregnation was continued until 6 lb. of phosphonate was retained per cubic foot of wood. The blocks were then seasoned in air for one month to remove substantially all the solvent. They were then tested according to the ASTM E-160-50 test. I and bis(2-chloroethyl) 2-chloroethanephosphonate both gave very good results. Textiles and paper can be made fire resistant by use of the same compounds. In other experiments, the antimicrobial action of I against *Aspergillus terreus, Rhizopus nigricans, Salmonella typhosa,* and *Staphylococcus aureus* was demonstrated. [Chem. Abs. V. 50, No. 8]

Economics

World pulp and paper resources and prospects. FAO, New York. 1954.

A survey prepared by FAO, in co-operation with UNESCO, ECE, and ECLA, and containing the following chapters: (1) Introduction; (2) The economic background; (3) Survey of potential demand; (4) World pulp and paper production, 1913 to 1950–52; (5) The situation in the regions (Europe, N. America, U.S.S.R., Latin America, Far East, Near and Middle East, Africa, Oceania); (6) The prospects for future developments in the deficit regions; (7) Conclusions; with appendices on forest resources, technical advances, inter-continental trade, newsprint problems, and the FAO Pulp and Paper Missions. [For. Abs. V. 16, No. 4]

Chapman, H. H. Pulpwood "economy" versus multiple products for southern pine. *J. Forestry,* 53, No. 8: 581–2 (Aug., 1955).

Reference is made to the establishment of two sample plots in Louisiana in 1935 (each 1/8 of an acre is size) for determining the effect of thinning on the growth and yield of loblolly pine and the relative profitableness of growing solely for pulpwood *vs.* the plan of producing sawlogs of quality with pulpwood as thinnings. The two adjoining plots, then 26 years of age, were closely comparable at the time as to site, number of trees, basal area, cubic and board feet volume, and rough cords. Plot 1 was thinned in 1935 at the age of 26 years, in 1940 at 31 years, and in 1952 at 43 years. Plot 2 was held as a check plot. The comparative yields of these two plots were measured at the age of 43 years; the comparison indicates that by making two or more early thinnings for merchantable pulpwood, the total yield in value may be increased by more than 80% as compared with one clear cutting at 43 years. Details of the calculations are given. [Bul. Pap Chem. V. 26, No. 3]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society. Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains over 1,500 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Review of FPRS Section Meeting Papers

Problems in the Fabrication of Helicopter Rotor Blades Using Veneer

Ken L. West, President, West Fabrication Laboratories, Annandale, N. J. FPRS Northeast Section Meeting Nov. 4–5, 1954, New York City.

Helicopter blades take a terrific vibration load which causes metal blades to fatigue at a very low life, while for this factor wood has infinite life.

To assure maximum strength, consistency in strength, and flexibility, laminated veneer and plywood construction is used in rotor blades. The laminated spar, the main structure which takes mostly centrifugal loads, is made up of 1/16-inch birch veneer to necessary thickness and length. Top and bottom skins, which are of thin molded plywood construction, are attached to the main spar to compose an airfoil.

One of the greatest problems in blade fabrication is balancing. For aerodynamic stability, a rotor blade must balance forward of the 25 per cent of the chord. This is done by adding ballast in the leading edge section. Since wood is not consistent in weight, each spur has to be balanced individually.

Another problem is conditioning the blades so there will be no change due to atmospheric weather conditions. Under normal atmospheric conditions, a wooden spar with perfect exterior finish will lose 2 to 3 per cent moisture content per year. In loss of moisture, flexibility characteristics change quite a bit. This has been overcome by the use of liquid wood stabilizers, two of which have been used successfully. A vegetable compound formula has given consistent moisture control over a period of three years. A drawback is that a delay of three weeks or more is necessary between application and finish. The other material, a liquid chemical, although it does not give as good stabilization as the vegetable compound, allows us to finish overnight.

The best exterior finish for a helicopter rotor blade is an alkyd resin. A material that would adhere to both alkyd resin and stabilized wood was a far greater problem when the vegetable compound was used than with the chemical formula as the vegetable compound had a tendency to bleed through. Up to ten coats of paint with wet sanding between each coat is necessary to get a perfect finish.

Wooden blades are being flown today with 5000 or more hours to their credit, while the maximum life of a metal blade is about 1000 hours. Although military agencies are specifying metal blades because of interchangeability due to consistency in weight and balance and because metal is less vulnerable to field handling, it is believed helicopter rotor blades in the future will not be all metal but a combination of wood and fiberglass. A blade made of this combination would lend itself to construction simplicity due to ease of molding, would have a durable exterior cover with an infinite life spar member, making it a perfect blade.

A Plan for Inspecting Purchased Veneer for Use by Small Woodworking Plants

David E. Wilson, III, Quality Control Supervisor, Owens-Illinois Plywood Co., Hancock, Vt. FPRS Northeast Section Meeting, Nov. 4–5, 1954, New York City.

Under the plan described in this paper, a quality control supervisor is in charge of all inspections in the plant and conducts personally those that can not be handled by any one of the production group. This plan was devised to give a minimum amount of time to purchased veneer inspection and still give management and production the information it needs.

All shipments of purchased veneer should be given rough visual inspection. A complete inspection should be given to any shipment from a new vendor. Every third shipment from a satisfactory regular vendor should be given a complete inspection. If a foreman notices any defective veneer, he should notify the qualtiy control supervisor and an inspection should be made for that particular defect.

In a complete inspection, the accuracy of the tools and their use are important. For veneer, a steel tape is used for checking lengths and widths, a micrometer for thickness, and a moisture meter for moisture content. A knowledge of veneer is important so the inspector can note defects and check their degree.

In most types of inspections, a sampling technique is used. In this particular plan, Military Standard Sampling Procedures and Tables for Inspection by Attributes, Mil-Std-105A, 11 September 1950, is adapted.

This method is suitable for small woodworking companies which can not afford a large inspector group. It will give satisfactory results, providing management with the necessary answers.

Industrial Opportunities in the State Forests of New York

C. D. Kingsbury, Superintendent, and C. F. Baar, Assistant Superintendent, State Forests, New York State Conservation Dept., Albany, N. Y. FPRS Northeast Section Meeting, Nov. 4–5, 1954, New York City.

The New York State Forest Program was initiated in 1929 primarily as an aid in the solution of the abandoned farm problem which existed at that time. The first step in the program was land acquisition. As of September 30, 1954, 550,427 acres had been purchased at $3.89 average price per acre. Of this acreage 264,514 acres have been planted with approximately 308 million trees consisting of such major coniferous species as white pine (22%), red pine (33%), Scotch pine (5%), Norway spruce (21%), white spruce (10%), larch (4%), and other species (5%).

Of the remainder of the half million acres purchased, approximately 218,000 acres consist of natural stands. While most of this acreage was in a depleted, over-cut condition at the time of acquisition, cultural improvement work has been done on about 162,000 acres. There is every indication that these acres will evenutally produce a highly valuable crop of species such as sugar maple, white ash, yellow birch, basswood and black cherry.

Of immediate concern is disposition of the small material (3- to 5-inch d.b.h.) being produced from first thinnings. If a market could be developed for this type of material we would have available an annual cut between the years of 1956–1959 of approximately 69,000 cords; 18,000 between 1960–1964; 10,000 between 1965–1969; 18,000 between 1970–74; 11,000 between 1975–79.

Little sawlog material will become available from these plantations prior to 1980, at which time the oldest plantation stock will be 50 years old and have a d.b.h. of between 12 and 14 inches. The final step in completing volume statistics is that of the residual volume which should be about 14.5 million cords in 1985.

Marketing of forest products is made through either local sales or bid contract sales. Local sales are not permitted to exceed $100; bid contract sales are used for everything over that amount. In the field of marketing we are, of course, definitely interested in experimental projects being conducted by industry with respect to the utilization of substitute species.

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FPRS News-Digest, Continued

Overlaid Veneer Applications

Ply–Veneer, a wood veneer panel stock overlaid with kraft linerboard, is being produced in several new constructions for the industrial packaging and light manufacturing fields, according to R. D. Pauley, Manager, Special Products Division, Weyerhaeuser Timber Co., Tacoma, Wash. The product's core is Douglas-fir veneer, mechanically distended by a patented process to increase dimensional stability under moisture.

Constructions now include three core thicknesses of 1/10 inch, 1/8 inch, and 3/16 inch. Each is available in a choice of three combinations of kraft linerboard facings—42 lbs. on both sides, 90 lbs. on both sides, or 42 lbs. on one side and 90 lbs. on the other.

The photo above shows Ply-Veneer used as a component part of restaurant booths. The 1/10-inch, 42–42 construction bends easily around corners, retaining dimensional stability, it is claimed.

White-one-side overlaid veneer is said to be meeting acceptance in furniture, toy, game, display, and exhibit manufacturing, as well as other fields. The surface is white bleached kraft linerboard laminated to the standard brown unbleached kraft facing.

Fire Fighting Pumper

A fire fighting pumper kit for pick-up trucks has been developed by H. S. Watson Co., Emeryville, Calif. The installation converts any pick-up truck into a fire fighter for lumbering and construction crews, forest rangers, game wardens, and others.

The pump, which is quickly mounted or demounted, takes its motive power from a power take-off shaft coming from the rear end of the truck. It develops up to 350 lbs. of pressure to make a penetrating fog spray that easily snuffs out a blaze, extending the usefulness of the 50 to 300 gallons of water that a light truck can carry. The rear-mounted drive is also an auxiliary power source for driving other tools. A booklet, "The Practical Way to Stop Fires Before They Spread" is available from the manufacturer.

Carbide-Tipped Tools

A new line of carbide-tipped tools under the trade name Kwik-Kut has been introduced by the Saw Division, R. Hoe & Co., Inc., 910 E. 138 St., Bronx, N. Y. Included are router bits, radius edgers and corner rounder router bits, double bevel shaper knives, bevel-edge trimmers, flush trim saws, helical wing cutters, slotting cutters for arbor mountings, and spur drills.

The firm has issued a catalog of information on care and maintenance of carbide tools, size charts, and other statistical data. A feature offered in promoting the new line is a tool resharpening service to be conducted by mail.

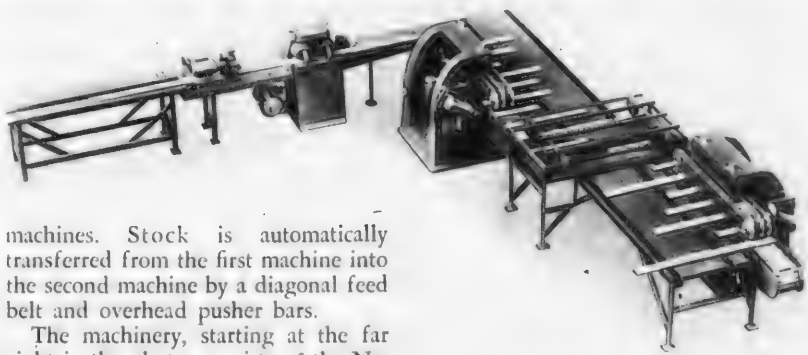
Finger-Jointing Machinery

A new group of closely coordinated finger-jointing and assembly machines has been developed by Greenlee Bros. & Co., Rockford, Ill. Bulletin FJM describes the machines, which turn potential waste and low-grade stock into profit through salvaging and upgrading lumber.

Finger joints of either the straight or angle type can be produced by changing cutting heads and adjusting the cut-off and scoring saws. The machines have a variable feed rate up to 90 feet per minute and can handle a range of stock sizes up to 2 inches thick, up to 6 inches wide, and down to a 6-inch minimum length.

Feed chains and hold-downs are arranged to feed the work for accurate cutting in both right and left-hand machines. Stock is automatically transferred from the first machine into the second machine by a diagonal feed belt and overhead pusher bars.

The machinery, starting at the far right in the photo, consists of the No. 565 right-hand finger-joint machine with side conveyor, followed by the No. 565–A automatic transfer and the No. 566 left hand finger-joint machine with side conveyor and glue applicator. At left center is the No. 567 assembly machine, which can be followed by a high-frequency curing unit. The last machine in the group is the No. 567–A traveling cutoff saw and outfeed table.



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Plastic Top Adhesive

A new glue for plastic top laminators has been developed by National Casein Co., 601 W. 80th St., Chicago 20, Ill. The glue, called No. 486, is a powder which reportedly gives a smooth, free flowing product when mixed with water. It spreads easily and can be readily seen because of its tan color.

The manufacturer reports this glue takes a deep "bite" on all kinds of hardboard, both tempered and untempered. It also bonds plastics and hardboards to particle board cores. The setting time on a typical construction of plastic sheet, plywood and hardboard is 30 minutes at 70° F. Other features reported are that the glue line will not gum up sandpaper or cutting edges and is both water and heat resistant.

FPRS News-Digest, Continued

NEW PUBLICATIONS

Selection of Windows. Federal Construction Council Technical Reprint No. 5 (in press). $1. Building Research Institute, 2101 Constitution Ave., Washington 25, D. C. Summary of four Federal agencies' and 13 architectural firms' practices relating to selection of windows. Contains opinions on advantages and disadvantages of various types and materials, suggested method for economic selection of windows, recommendations, and bibliography.

71 Homes Projects in Wood. 35 cents. National Lumber Manufacturers Assoc., 1319 18th St. N. W., Washington 6, D. C. Consumer booklet giving details for building wide range of items for home and garden.

Yield Table Conversion Factors Make 'Quick Cruising' Quicker. J. H. G. Smith and J. W. Ker. Faculty of Forestry, U. of British Columbia, Vancouver, B. C. Reprint from British Columbia Lumberman.

Technical Digests. Annual subscription, $24. Organization for European Economic Cooperation, 2000 P St. N. W., Washington 6, D. C. Translations and digests of articles from European technical and industrial journals.

A Report to the Governor of North Carolina. West Virginia Pulp and Paper Co., 230 Park Ave., New York 17, N. Y. Outlines importance of firm's forestry program to the state, stressing number of persons employed, thoroughness and scope of fire prevention and control measures, and tree planting program.

Chemical Debarking of Some Pulpwood Species. 60 cents. Dept. of Forest Extension, State U. of N. Y. College of Forestry, Syracuse 10, N. Y. A 60-page technical publication explaining how bark can be most readily removed by chemical means and various problems involved in this process.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

List of Publications on Wood Preservation. Report 704. Gives results of research by FPL on preservative materials, methods of application, and effectiveness of various treatments.

Information Leaflet on Foreign Woods. B. F. Kukachka. Report 2051. Presents data on seasoning characteristics, mechanical properties, workability, durability, and utilization of palosapis, a Philippine hardwood.

List of Dry-Kiln Companies and Engineers and Consultants in the United States. Report 1031.

Temperatures Necessary to Kill Fungi in Wood. M. S. Chidester. Technical Note 259. Presents time-temperature schedules for the killing of various fungi that are destructive to wood.

Standard Terms for Describing Wood. J. A. Liska and J. T. Drow. Report 1169 (revised). Presents a system of standard descriptive terms for six important properties of wood and gives in tabular form the comparative strength values and the corresponding descriptive terms for 178 species of wood grown in the United States.

List of Publications on Structural Sandwich, Plastic Laminates, and Wood-Base Aircraft Components. Report RPI–4.

Comparison of Wood Preservatives in Stake Tests (1956 Progress Report). J. O. Blew. Report 1761. Seventh in a series of annual reports that describe the condition of treated and untreated stakes of southern pine and of modified-wood products, such as plywood, impreg, compreg, staypak, and papreg, and compare the effectiveness of the wood preservatives used.

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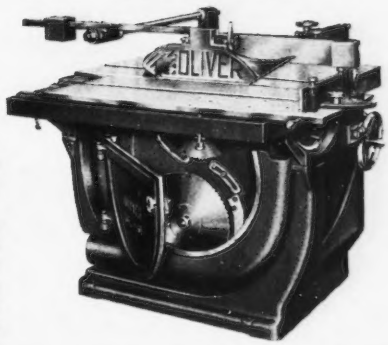

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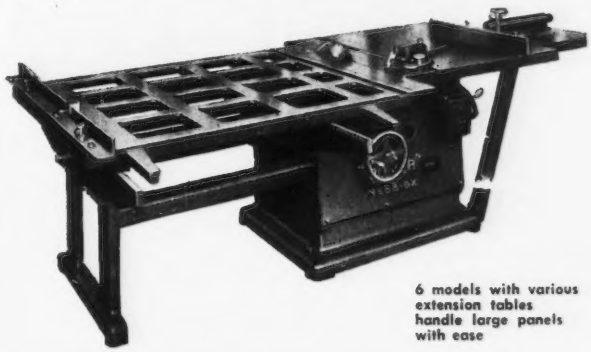

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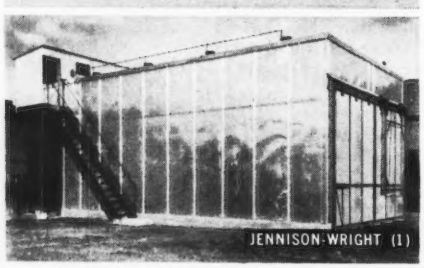

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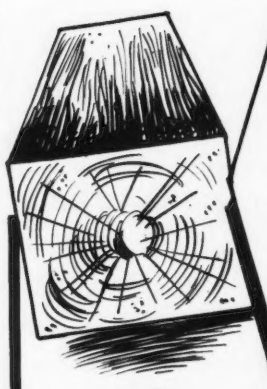
INDEX TO ADVERTISERS

	Page
American Cyanamid Co.	2nd Cover
Behr–Manning Corp.	2–A
Black Brothers Co., Inc.	4–A
Buss Machine Works	5–A
Chapman Chemical Co.	3–A
Fjellman American, Inc.	4th Cover
Greenlee Bros. & Co.	8–A
Koppers Co., Inc.	15–A
Laucks Laboratories, Inc.	27–A
Macmillan Co.	28–A
Mattison Machine Works	3rd Cover
Morton Salt Co.	6–A
Oliver Machinery Co.	27–A
Radio Receptor Co.	7–A
W. H. Rambo	25–A
Reichhold Chemicals, Inc.	14–A
G. Siempelkamp & Co.	13–A
Standard Dry Kiln Co.	28–A
Williams Patent Crusher and Pulverizer Co.	24–A
Williams–White & Co.	16–A
Wood Treating Chemicals Co.	26–A



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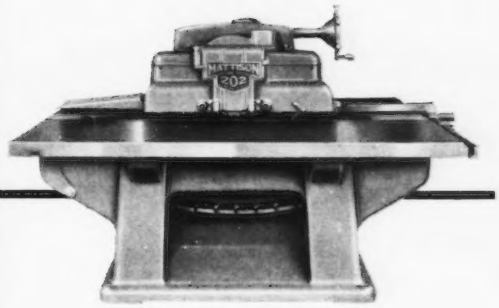

The Mengel Company, Louisville, Ky., has found that Mattison Model 202 Rip Saws are an important component in their conveyorized production lines.

Accuracy of these machines makes possible production of glue joints without the extra step of going through the glue jointer. Three saw lines use either four or five Model 202 Saws ripping stock from cut-off saws. Dependable operation and high production have been characteristic of these saws over their many years of service for Mengel.

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WOODWORKING MACHINERY

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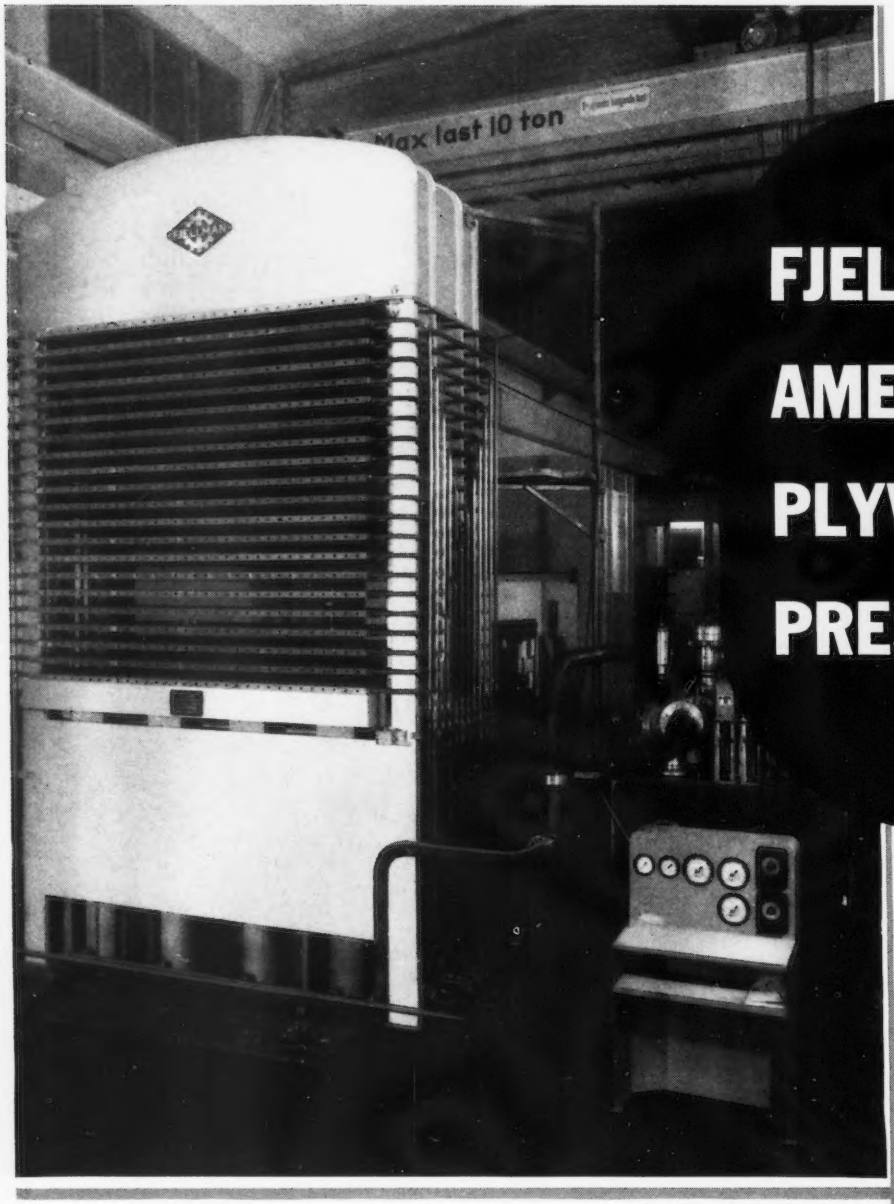

FJELLMAN AMERICAN PLYWOOD PRESSES

Platen area 54" x 106"; 200 PSI over the entire platen area; total pressure, 572 tons.

Fjellman American enjoys close association with fine quality plywood production throughout the world. An impressive list of installations in leading plywood producing plants is available on request.

Reasons for Fjellman American's predominance in the industry lie in the all-Swedish steel construction of its presses eliminating dead weight in castings, light floor loading, easy installation, accuracy and long lasting dependability. Fjellman American's quick closing automatic presses give you the guaranteed constant pressure and uniform heat necessary to produce the finest plywood in the world.

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